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Kondo, Tamiyo

Takemoto, Shogo

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Scenario Planning Approach to Pre-Event Planning for Post-Disaster Recovery: The Case of the Future Mega-Tsunami Striking Kushimoto, Japan

Tamiyo Kondo[†] and Shogo Takemoto

Kobe University
1-1 Rokkodai, Nada-ku, Kobe, Hyogo 657-8501, Japan
[†]Corresponding author, E-mail: tamiyok@people.kobe-u.ac.jp
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Previous studies have argued the significance of pre-event planning for post-disaster recovery. We examined how scenario planning approach is effective for pre-disaster planning. We applied scenario planning approach to develop strategies for multiple possible futures of the case study city, expected to hit by a massive tsunami following the Nankai Trough earthquake. Our analysis reveals the adaptive and transformative strategies for multiple scenarios. Uncertainty surrounding dynamic recovery processes need to enforce transformative strategies to reframe the Japanese planning paradigm in post-disaster recovery.

Keywords: pre-event planning for post-disaster recovery, scenario planning, land use planning, collective residential relocation, the Nankai Trough earthquake

1. Introduction

There is a 70%–80% probability of a tsunamigenic Nankai Trough earthquake of magnitude 8–9 occurring within 30 years, and its enormity and high probability of occurrence is a national crisis for Japan. We explore how scenario planning approach is effective for pre-event planning for post-disaster recovery in the case of the future mega-tsunami striking Japan. We applied scenario planning methods to develop multiple scenarios and examined strategies which enable to response to negative effects of recovery process and transform the future in the case study city. Scenario planning is a business tool which allows companies to visualize the impact of possible futures and help their strategic planning process. It is "a tool for action, not for planning" [1]: aims to contribute to strategic decisions under uncertainty, rather than seeking accuracy in future predictions. We chose the Kushimoto Town, Wakayama Prefecture as the case study city, and investigated their pre-event planning for the future mega-tsunami. The reason why Kushimoto Town was chosen is that the municipality has already implemented and been planning land use mitigation measures including public facilities and collective residential relocation to higher ground. We conducted two interviews about: tsunami mitigation measures and its funding for government officials in the disaster management section (February 24, 2017), and planning for residential relocation and its discussion process for the mayor (April 6, 2019). We also visited the higher ground relocation site in 2018 and 2019.

2. Government-Planning in Kushimoto

2.1. Demography, Industry, and Exposure

Japan is one of the most rapidly ageing and depopulating countries. Kushimoto Town is in more advanced stages: aging population of 43.0%, which is 1.6 times the national average of 26.7%. In 2010, the town was designated as a depopulated area based on the Act on Special Measures for Promotion for Independence for Underpopulated Areas, and issued local bonds authorized by the act to build public hospitals and fishing port facilities. Main industries of the town are fishery and tourism. This is established by affluent and exclusive natural resources including fishing ground for tuna farming, coral reef for scuba diving, majestic landscape for geotourism. Decreasing of working-age population is also crisis for lack of individuals succeeding fishing industry. More than 80% of the total area in Kushimoto Town is occupied by mountains, forests, and hilly areas, while flat areas are scattered along the rias coast and rivers. The location is not only vulnerable for typhoon but also for tsunami: estimated to experience 17 to 18 meters tsunami that can reach the town within three minutes which is the first tsunami arrival in Japan.

2.2. Town Office's Pre-Disaster Recovery Efforts

Wakayama Prefecture has designated 19 cities including Kushimoto Town in the prefecture as yellow zone based on the Act on Regional Development for Tsunami Disaster Prevention. Designation of zones for land use regulations with building restrictions has not been implemented. Municipality is planning to conduct a cadastral survey, investigating owner, parcel number, type of land, boundary, and the dimension for every parcel of

Fig. 1. Relocation projects to higher ground. Source: by author, base map from Google Earth.

land which clarify the land rights. Recovery after the 2011 tsunami was significantly delayed due to a lack of cadastral data and land-ownership information.

Kushimoto Town's strategy for reorganizing land use is to move public facilities to higher ground first, and then encourage low-lying area residents to relocate there (**Fig. 1**).

The relocation of the public hospital (2011), the disaster management center (2012), and the town hall (2021) has been already completed. Approximately 80% of construction cost of the town hall building, 3.3 billion yen, was financed by local government bonds: bonds for emergent disaster prevention (2.38 billion yen) and special purpose municipal bonds after amalgamation (0.3 billion yen), and the remaining amount comes from town's general account budget [2]. National treasury disbursement, local allocation tax measures, have been taken to cover the 70% to issue of both bonds. The collective residential relocation to higher ground, on the other hand, is still in planning process. Wakayama Prefecture encourages municipalities to promote collective residential relocation. They introduce successful collective residential relocation projects after the 2011 tsunami in their redeveloped guidebook of pre-event planning for disaster recovery. However, it can be easily imagined that it will not be easy to enforce people to leave their home and restrict their land use without experiencing tsunami damage. The word "residential" relocation to higher ground does not appear in any municipality's plans such as "Plan to promote regional development for tsunami disaster prevention" or "Regional plan for national resilience." The main reasons for this are that the project funding is not yet secured, and the municipality cannot ask residents' willingness to participate collective relocation without those funding incentives. The town uses the opportunity offered by the construction of national expressway to promote higher ground development. The extension of the Kinki Expressway from Osaka to Kushimoto is under construction by national government. Expressway is expected to be used not only emergency transportation road in case of disaster but also as residents' commuting and tourists' accessibility during normal times. They need temporary construction road for the project. Kushimoto Town made a proposal to reuse this construction road as their permanent roads network which also works as tsunami evacuation routes for community (**Fig. 1**). This was approved by the national government. The road runs through the undeveloped mountains behind the town center, leading from the low-lying area to higher ground. Collective residential area is planned to develop along the road, together with a disaster prevention park for evacuation and other facilities. In addition, the remaining soil from the expressway construction work is being used to create a flat area to secure land for developing temporary housing site (**Fig. 1**). Reorganizing land use urges public transportation network to ensure residents' mobility. There are few public community transportation bus services which connects low-lying area and higher ground, and no plan to increase and extend the network as of now.

3. Scenario Planning

3.1. Set Two Driving Forces for Uncertain Future

Scenario planning starts by setting up two uncertainties that diverge the future. They are called key-driving forces which satisfy the following criteria: no correlation with each other, a large potential impact, and high uncertainty [1]. Given the broad regions affected by the Nankai Trough earthquake, we determined the external environment that affects the Japanese macro economy as the driving force: government's financial resources for recovery and the supply-demand gap in the construction industry. These axes were set by Nagamatsu and Hayashi [3] who developed a macroeconomic recovery scenario for the future Tokyo metropolitan earthquake. The reasons for using these axes in our article are as follows. The 2011 post-tsunami recovery was dependent on the financial resources of the national government. The national budget invested in the recovery from the Great East Japan Earthquake amounted to about 32 trillion yen. In the event of the Nankai Trough earthquake, the scale of the budget will become even larger if we apply same urban planning patterns implemented in the 2011 tsunami. Maki [4] estimated the recovery budget for the Nankai Trough earthquake would exceed 100 trillion yen, which is equivalent to the Japan's national general account expenditure. The other axis, supply demand gap in construction is based on the experience after the Great East Japan Earthquake and the Kumamoto Earthquake in 2016 (two M7.2 earthquakes). The gap between supply and demand in construction costs delays the start of housing reconstruction and causes soaring construction costs following the 2011 and the 2016 earthquakes [5].

3.2. Develop Multiple Scenarios and its Methods

Scenario planning starts by setting up two uncertainties that diverge the future. With the combination of two axes, we created four scenarios based on the following inputs: countrywide practice in pre-event planning, macroeconomic trends as external environment, and internal environment of the town including government and residents' efforts and awareness for pre-event land use mitigation planning. The developed scenario assumes that the post-Nankai Trough earthquake follow urban planning pattern implemented after the 2011 tsunami and results in similar consequences [6–15]. Two axes provide to envision different macroeconomic situation, and local preparedness and awareness are input data to draw up scenarios. Then, we developed two types of strategies for multiple scenarios: "adaptive" strategy to cope with negative cascading consequence of recovery process, and "transformative" strategy to change the future [16].

Scenario 1: Sustain. Financing of reconstruction proceeds smoothly and there is surplus production capacity in the domestic construction market [3]. As a result, the construction of collective residential areas on higher ground and the redevelopment of low-lying areas progressed smoothly. The early developments allow survivors to complete their housing reconstruction at an early stage. Fishery-related industries can reconstruct their facilities. The town is successful to maintain the population.

Scenario 2: Polarization and fragmentation. Financing of reconstruction proceeds smoothly, but there is not enough surplus production capacity in the domestic construction market. As a result, urban development projects and public disaster housing construction delayed. People migrated to non-affected area to restart their lives. Temporary housing residents outside the town decide not to come back to the town. This enlarges the number of vacant parcels on the raised ground and collective relocation subdivision. Also delay of coastal dike make people feel highly anxious to stay in low-lying area which trigger residents' relocation and destruct their long-time community. Internal migration fragment community into people who can afford to buy new land to construct new housing and people who are not able to do so. Elderly population who relied on community ties face difficulty in continuing their lives in low-lying area. Rising construction costs force homeowners to give up rebuilding their housing, increasing the demand for public disaster housing. The development of low-lying areas is delayed, making it difficult to resume fishery-related businesses. As a result, people and businesses move out of the town.

Scenario 3: Economically distressed. The GDP decreases, unlike scenarios 1 and 2. The yen weakens, and interest rates rise due to the great concern about financial ruin [3]. It is difficult for tourism sector to secure funds to restart their business, and the livelihood of survivors worsens as bankruptcies of affected small and medium-sized businesses increase. Raised ground and collective relocation site are completed, and ready to start housing rebuilding, however, they cannot find building constructors for their housing reconstruction. Residents become increasingly dissatisfied as they wait for rebuilding resulting in relocation to unaffected areas where they can find constructors or outside disaster-stricken area which have sufficient stock of existing houses. Vacant lots in redeveloped area put fiscal burdens on municipality to maintain public infrastructure with less tax revenue. Some residents rebuild their housings on higher ground; however, there is not enough bus service to go shopping in low-lying area. Elderly people cannot walk to shopping, tend to stay in their homes which lead to deterioration of health, failing to form new community, and isolate themselves in the community.

Scenario 4: Marginal settlement. The price of materials needed for recovery rises due to the depreciation of the yen, and there is not enough surplus production capacity [3]. Investment in recovery shrinks, making it difficult to implement urban development projects, and a significant population decline occurs. As the town's tax revenue declines, it becomes difficult to provide adequate public services. The negative chain of events continues, as the town becomes difficult to sustain lives, the population moves out on a large scale, and making the town unsustainable.

3.3. Develop Strategies for Multiple Scenarios

We examine two types of strategies: adaptive strategies to mitigate the negative effects and transformative strategies to change the future.

As for adaptive strategies, municipality needs to downsize the number of residential subdivision parcel to respond to demand decrease in raised and higher ground. Housing reconstruction delay induces outflow migration from the affected area in either scenario. If large scale urban planning project inevitably led to its prolongation, we have to decide not to follow the 2011 pattern. How about transformative strategies? Post-disaster planning intervention cannot control outflow and internal migration. Reorganizing land use with necessary measures before tsunami works. These measures include moving community together and ensuring mobility both of which enable to sustain their lifestyle. This is nothing more than making cities livable.

4. Discussion

4.1. Synthesis

We discuss the following questions: How could we interpret and assess the significance of multiple scenarios and developed strategies? What strength does scenario planning have compared to existing practice?

"Recovery Simulated Drill" by Ichiko [17] and Nakabayashi et al. [18] and "Recovery Image Training" by Kato et al. [19] are pre-event training for the future Tokyo metropolitan earthquake. The drill was developed based on the experience of the Great Hanshin-Awaji Earthquake (1995). Ichiko [17] emphasizes to pre-

experience the community recovery process and identify what they must prepare for the process. The training by Kato et al. [19] examines the necessary measures by picturing an image of the recovery situation from the combination of the people's livelihood restoration and the urban disaster recovery. The focus is to develop the method to simulate the recovery process and its challenges. Government officers develop the urban spatial vision for recovery. The output is action needed to balance people's livelihood restoration and the urban disaster recovery. The other two are pre-event planning for the Nankai Trough earthquake. "Planning to sustain local inheritance" by Iwaka et al. [20] and "Planning to sustain community activities" by Kim et al. [21] started after the 2011 tsunami. Their focus is to preserve local resource and sustain community activities, not developing something new. The question is how people could sustain their community in the face of two risks which endanger the survival of region and community: tsunami risk and population decline. The output is comprehensive community plan with vision. These two planning are nothing but livable city making which we come up as transformative strategies for Kushimoto in the result section. This suggests the integrating "Planning for sustainability and livability" with scenario planning approach is worthy of consideration for pre-event planning. What is the difference between our scenario planning approach and preceding methods? Preceding practice can be called us "vision-driven planning" with means of achieving a goal. Vision is determined by internal environment: what people wants. There is an assumption that they can reach the goal through deliberate thinking and action. In comparison to these approaches, our approach starts from variety of future not only determined by internal environment but also external environments. Developed scenarios in results section demonstrate the volatility for possible future: difficult to anticipate and control the recovery pass. Also, developed strategies show that affected city cannot avoid unsustainable without transformative strategies. Adaptive strategies can only mitigate negative effects but cannot change the future.

4.2. Limitations

Scenarios and strategies for the Kushimoto Town are developed only by author without residents and municipality officers' inputs due to COVID-19 crisis. Scenario planning works well by stakeholder engagement and diversity among stakeholders [16,22,23]. Multi-stakeholder involvement enables to develop more diverse scenarios and strategies to change the future. Our next step is to promote scenario planning by involving the town officers and residents.

5. Conclusion

This article explores how scenario planning approach may be effective for pre-disaster planning for post-disaster recovery through deductive reasoning. Vision-driven approach determines what to do to reach the desirable future, but the scenario planning approach identify how to change the systems and attitudes not to reach to undesirable future. Uncertainty surrounding dynamic recovery processes need to enforce transformative strategies to reframe the Japanese planning paradigm in post-disaster recovery.

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Name:
Tamiyo Kondo

Affiliation:
Associate Professor, Graduate School of Engineering, Kobe University

Address:
1-1 Rokkodai, Nada-ku, Kobe, Hyogo 657-8501, Japan

Brief Career:
2003 COE Researcher, Disaster Prevention Research Institute (DPRI), Kyoto University
2004- Research Scientist, The Great Hanshin-Awaji Earthquake Memorial Disaster Reduction and Human Renovation Institution (DRI)
2008- Associate Professor, Kobe University

Selected Publications:
• T. Kondo and G. Lizarralde, "Maladaptation, fragmentation, and other secondary effects of centralized post-disaster urban planning: The case of the 2011 'cascading' disaster in Japan," Int. J. of Disaster Risk Reduction, Vol.58, Article No.102219, 2021.
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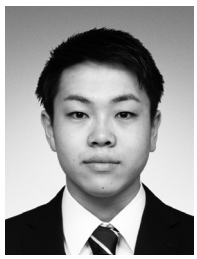

Name:
Shogo Takemoto

Affiliation:
Construction Management, Osaka Gas Co., Ltd.

Address:
4-1-2 Hiranomachi, Chuo-ku, Osaka, Osaka 541-0046, Japan

Brief Career:
2021- Osaka Gas Co., Ltd.