3-Year Research Program on Risk and Crisis Management Strategy for Excessive and Multiple Actions of Natural Disasters

by

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ABSTRACT

NILIM has started a new 3-year research project on "Risk and Crisis Management Strategy for Excessive and Multiple Actions of Natural Disasters (EMAND)" from 2012. Based on the lessons learned from the destructive damage caused by the 2011 Great East Japan earthquake, the research objective of the project is to improve Japan's emergency management capability (preparedness and responses) against extreme natural disasters including earthquake, heavy rain, flood, volcano, slope failure and the complex. The key words of the research is "Think outside the Box," and "Beyond the Estimations," as well as "Not Only Disaster but the Complex Disasters," to include concepts and thoughts to respond the disaster phenomenon with low frequency but high impacts. This paper presents the outline of the project including objectives, research issues and target outcomes.

KEYWORDS: Emergency Management, Excessive and Multiple Actions of Natural Disasters (EMAND), Preparedness, Research Project, Response, Risk and Crisis Management

1. INTRODUCTION

During Great East Japan earthquake of March 11, 2011, the giant tsunami which exceeded the past estimation and the strong shaking attacked to the Pacific sea side of Tohoku to Kanto regions, and caused catastrophic damage in wide area over the length of 500km. After the 5 months of the earthquake, the typhoons of #12 and #15 also attacked the affected area and the flooding and sediment disaster followed on the earthquake. Thus, the damage and impacts became complex phenomenon.

Important lessons learned from the earthquake and the following flood disasters are as:

1) Improvement of preparedness to natural disasters which exceed past experiences and the estimation

2) Preparedness for effects of multiple and combined actions of natural disasters including earthquake, tsunami, heavy rain, flood, slope failure and so on.

These aspects were pointed out in the Committee for Technical Investigation on Countermeasures for Earthquakes and Tsunamis Based on the Lessons Learned from the "2011 off the Pacific coast of Tohoku Earthquake," the Central Disaster Management Council [1]. The committee issued the following recommendations in September 28, 2011.

1) Consider scientifically possible maximum scale of earthquake and tsunami

2) Recognize possibility of uncertainty in the estimation

3) Conduct every possible efforts for disaster mitigation to expected trench-type and inland-type earthquakes

4) For the damage assessment, consider combined movement of estimated fault zones and the occurrence time (day or night time), and the combination with typhoons

Reconstruction Headquarters in response to the Great East Japan Earthquake, Government of Japan, developed "Basic Guidelines for Reconstruction in response to the Great East Japan Earthquake," and issued it on July 29, 2011. The basic policies are the followings.

1) To make resilient and disaster-resistant society, put every possible effort based on "mitigation/evacuation" concept rather than "prevention"

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2) Strengthen national land to prepare large scale disasters
3) Make tough and ductile multiple defense concept

Based on the lessons learned from the destructive damage caused by the 2011 Tohoku earthquake, NILIM has started a new 3-year research project on "Risk and Crisis Management Strategy for Excessive and Multiple Actions of Natural Disasters (EMAND)" from 2012. The research objective of the project is to improve Japan's emergency management capability (preparedness and responses) against extreme natural disasters including earthquake, heavy rain, flood, volcano, slope failure and the complex. The key words of the research is "Think outside the Box," and "Beyond the Estimations," as well as "Not Only Disaster but the Complex Disasters," to include concepts and thoughts to respond the disaster phenomenon with low frequency but high impacts. This paper presents the outline of the project including objectives, research issues and target outcomes.

2. OBJECTIVES OF THE RESEARCH

The objective of the research is to clarify, define and measure the occurrence and the impact of the excessive and multiple actions of natural disasters which had not been considered in the past, and to propose the technology to enhance and improve the emergency management structures.

As shown in **Fig. 1**, there are several types of hazards including earthquake, tsunami, flood, volcano, storm surge and slope failure. The countermeasures have been constructed to treat each disaster independently in the past, the target of the research is to cover the area of the possibility to exceed the expected level (design level) and the combined impacts of multiple disasters. Foe example, complex action includes the flooding after the earthquake (as the case of 2011 Great East Japan Earthquake), and sediment and flooding disaster caused by the rainfall after the volcano eruption.

For these objectives, the research focuses on the following 3 points.
1) To know fully about EMAND
2) To see through EMAND, and
3) To manage coolly EMAND

Fig. 2 shows the illustration of countermeasures to EMAND.

3. RESEARCH ISSUES

3.1 Collection and Re-Analysis of Past Disasters

To know fully EMAND, the data of the past disasters and damage experiences is now being collected and re-analyzed. The different points from the past research are to learn again what happened and to think what will happen even though there has been no actual experience. Approach to consider both actual events and possible events with no experience is used for the analysis.

The events of disaster and the chain spreading influences to the society are to be studied using tree diagram concept. **Fig. 3** shows just a simple example of tree diagram. The earthquake occurs, and the disaster events including tsunami, liquefaction, ground settlement and cracks and sliding are caused. And such events furthermore cause next events and increases risks. The research focuses on clarification of disaster mechanism again because these approaches can enhance the capability not to miss all possible important disaster events and can be the base of flexible disaster management with well understanding of disaster phenomenon.

Past disasters to be analyzed include the 2011 Great East Japan Earthquake, 2012 Hurricane Sandy in US, and other recent large disasters in and out of Japan. Attention is also paid to the historical disasters to be analyzed. **Fig. 4** shows examples of historical disasters occurred in Japan. One is the Ansei earthquake in 1858. Large landslides occurred and developed the landslide dam. The dam failed by the aftershock, then flooding attacked the residence area. The other is Tenmei eruption of the Asama mountain in 1783. Pyroclastic flow developed sediment dam and the dam failed. In 1786, 3 years after the eruption, over 1000 people were killed by the volcanic

mud flow. Social and economical situation when such historical disaster happened is completely different from the current one, but the attention is just paid to every experience.

3.2 Development Methods of Scenarios and Evaluation of Risk and Impact

To see through EMAND, scenario based evaluation methods for disaster occurrence and its chain progress is being studied as well as the risk evaluation methods to measure the size and the importance of the risk of events quantitatively. It is essential to understand how large the effect of the disaster and what must be protected and what is effective countermeasures to minimize the effects.

Based on the re-analysis of actual disasters as described in the above, the method to build scenario structure of events dependent on the social and economical conditions of the regions, which caused by the earthquake, heavy rain, volcano and others as well as the combinations, is being studied. As a typical model region is assumed to include mountain, flat, coastal, and urban areas. The social characteristics such as the population and the industry must be considered.

Based on these scenarios, the size of risk/influence is computed to evaluate the disaster quantitatively. The evaluation key index is assumed to be casualty and direct/indirect damage cost. The evaluation methods of risk and the influence should consider the mitigation effect by the applied countermeasures.

It is essential for the development of the scenario to setup the chain spreading of the damage and the events. **Fig. 5** shows a simple image of impact chain spreading of the damage of infrastructures to the society. The damage to roads, for example, causes the disfunction of the roads and results in the delay of recovery activities and the lack of emergency goods and equipment, then affects the society. For example, in the case of flooding, the inundation to underground spaces causes the fail to escape of people there. The power down caused by the water is also one of the important chain spreading mechanisms. During the 2011 Great East Japan earthquake, the lack and shortage of the gasoline, which caused by the damage to the oil refineries in the area, was also one of the biggest chain spreading.

Thus, the developed disaster scenario for a model region, the impact size by the index of casualty and/or damage costs is evaluated dependent on the level of the excessive and multiple actions of natural disasters. **Fig. 6** shows an example of evaluation index of disaster risk and impacts proposed by the USACE. The relation between the number of casualty and the occurrence probability of the casualty is shown. From **Fig. 6**, the occurrence probability to cause casualty of 100 is about one millionth. Aspects on the acceptable risk for the public and the cost of countermeasures to minimize casualty is necessary to be studied.

3.3 All-out Mobilization Concept of Countermeasures

To manage coolly EMAND, based on the scenario and the impact index as described in the above, the effective and possible countermeasures to minimize the risk and impacts, and to hold back the chain spreading with large effects are studied. The combination of the prevention, mitigation, and evacuation countermeasure concept, and the multi-level protection concept depending on the level of disasters are studied. The countermeasures include the provision and improvement of disaster prevention/mitigation infrastructures, and the improvement of emergency management system to respond to the disasters. The multi-level countermeasure concept means that the upper limit of hazard level may not be considered. **Fig. 7** shows the multi-level disaster response concept dependent on the level of disasters. When the level of hazard becomes larger, the disaster impact also increases, and the countermeasures and the response policy also should be changed to be appropriate to the level of disasters. The impact index curve for a big city area and a rural local area are shown in **Fig. 7** as examples. To consider the disasters without upper limit, it is an important point to recognize the inflection point that the impact index remarkably increases with the increase of hazard

level dependent on the regional characteristics. Based on such analyses, it is possible to recognize what should be protected primarily dependent on the level of hazards. Even when the disaster exceeded the expected level, it is essential to always provide the next move.

Fig. 8 shows just an example of the menu of countermeasures. This shows a matrix of countermeasures before and after the events, and of those by the provision of protective infrastructures from the disasters and by the planning and information to protect human lives. One of the research targets is to provide the menu of effective measures. The tree diagram as shown in **Fig. 5** is to be used to find out what the efficient method to stop the chain spreading is. Risk curve as shown in **Fig. 6** is to be used for the development of disaster prevention infrastructures and for the quantitative evaluation of the selection of the countermeasure menu. The efficient methods are selected within the acceptable risk and the necessary costs to do those.

4. TARGET OUTCOMES

The research has been got down to from last April. The target of outcomes is the "Development of Countermeasure Guidelines on Disaster Mitigation Technology Application." The guidelines include the standard scenario development method and the impact index evaluation method to consider EMAND, as well as the countermeasure menus based on the multi-level disaster response concept. The guidelines are expected to be one of useful references for the application of the disaster response planning and the selection of the countermeasures. It is expected to be used for the assessment of the disaster capability of local regional and national levels. The important point is to extend the idea of outside the box and beyond the estimation not to limit a certain level. It is also important issue to know the limit of the protection infrastructure and provide the next move even if the provided protection is failed. The combination with the information and evacuation technology to save lives, and the quick function recovery just after the events and the systematic permanent rehabilitation technology are also essential. Such technology development and improvement will result in the development of the resilient society. The outcomes are expected to apply for the rehabilitation from the Great East Japan earthquake and to prepare next events including the Nankai Trough Giant Earthquake with M9.

5. CONCLUSIONS

The research project has been conducted jointly by Research Center for Disaster Management and River Department of NILM. To make the research outcome into practice, the research will be made in cooperation with MLIT Headquarters and Regional Bureaus. NILIM will try to cooperate or exchange technical information with academic community and foreign countries through the channels including the US-Japan Panel on Wind and Seismic Effects, UJNR, in order to make results be informative considering a wide area of disasters with low frequency and high impact.

It should be note here that the project is included in the MLIT's Master Plan for Technology Development which was issued by the Panel on Infrastructure Development on Dec. 10, 2012. The MLIT master plan is to show the policy direction of technology development and the efforts on R&D to be proceeded with a high priority.

6. REFERENCES

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2. Reconstruction Headquarters in response to the Great East Japan Earthquake: Basic Guidelines for Reconstruction in response to the Great East Japan Earthquake, July 29, 2011, http://www.reconstruction.go.jp/topics/doc/20110729houshin.pdf

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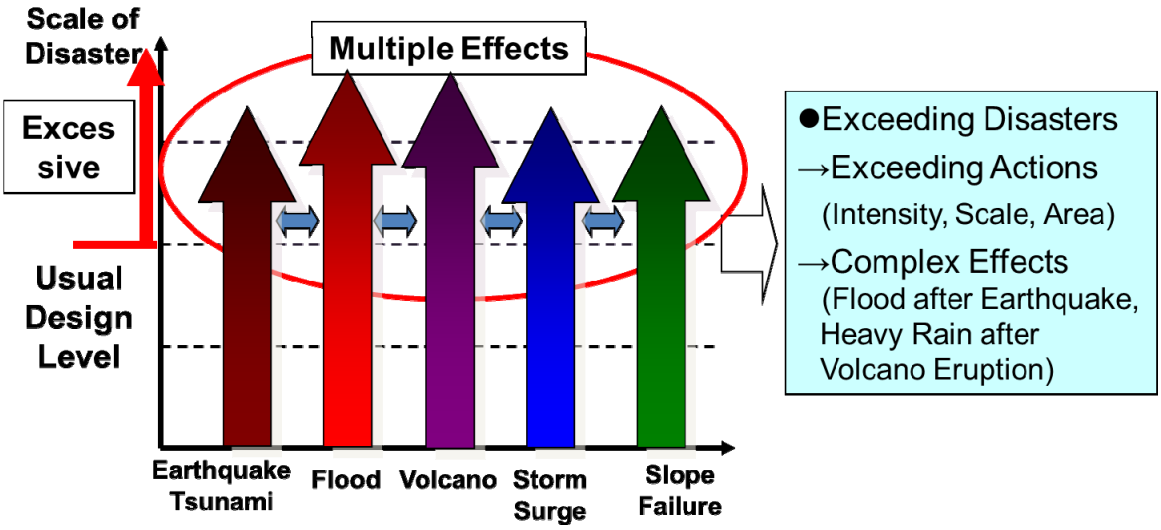

Fig. 1 Excessive and Multiple Actions of Natural Disasters

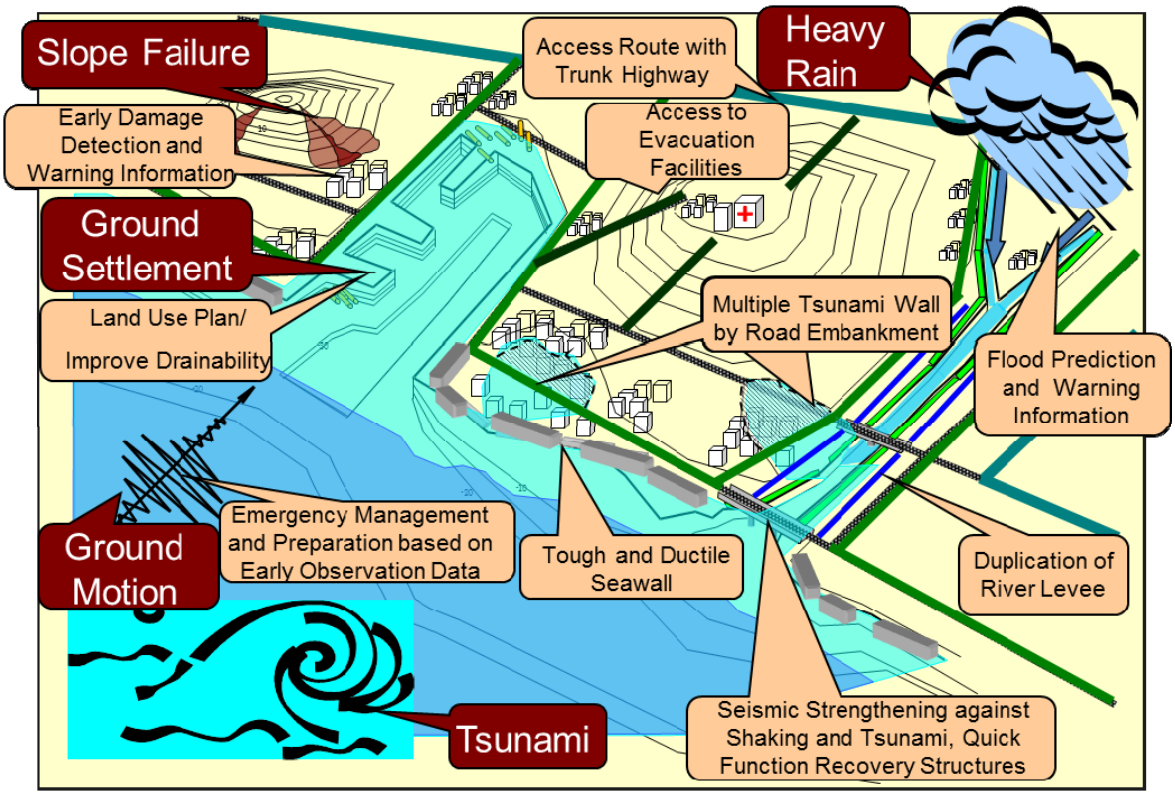

Fig. 2 Illustration of Countermeasures to Excessive and Multiple Actions of Natural Disasters

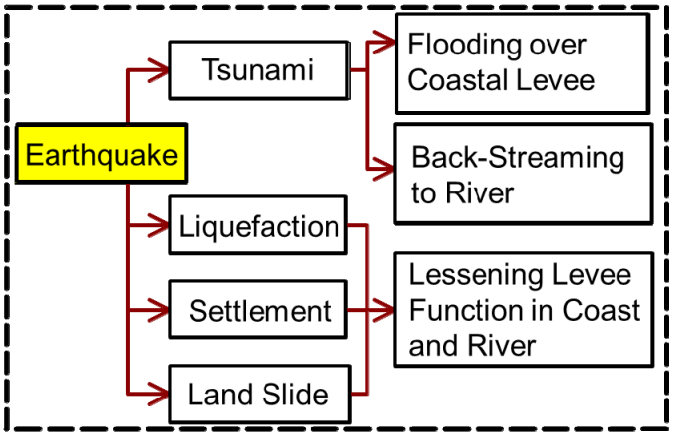

Fig. 3 Damage and its Chain Impacts

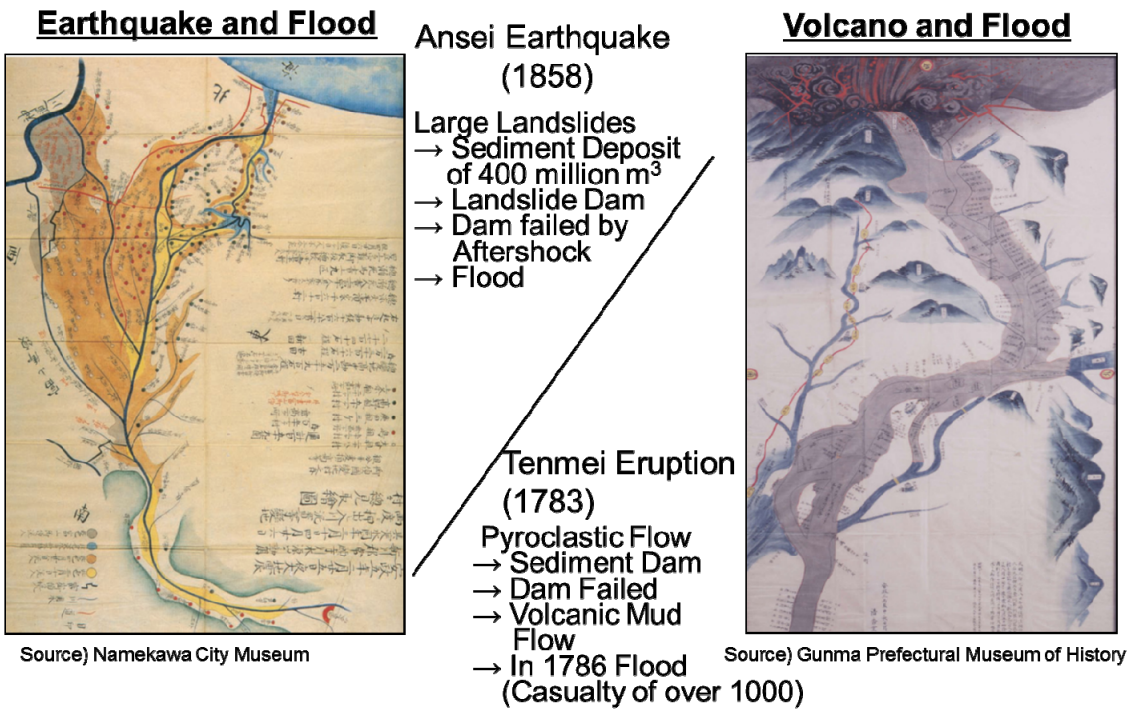

Fig. 4 Historical Complex Disasters in Japan

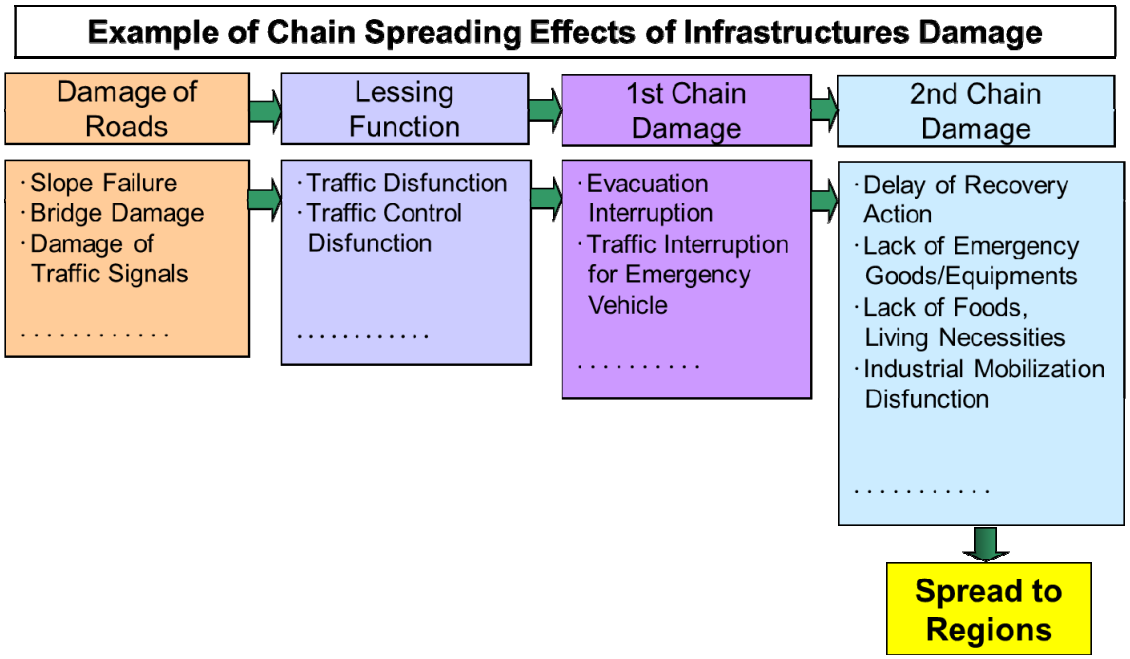

Fig. 5 Select out of Impact Spreading to be considered in development of Disaster Scenarios

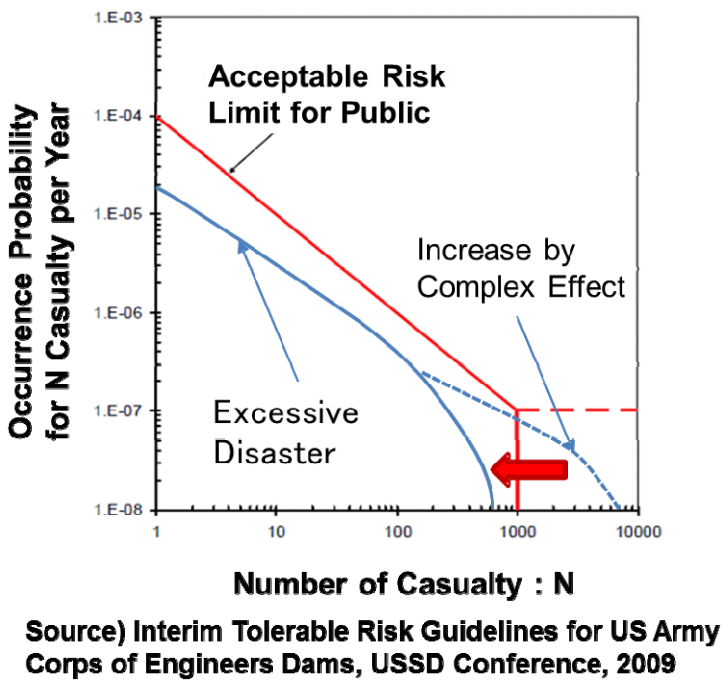

Fig. 6 Example of Evaluation Index of Disaster Risk and Impacts

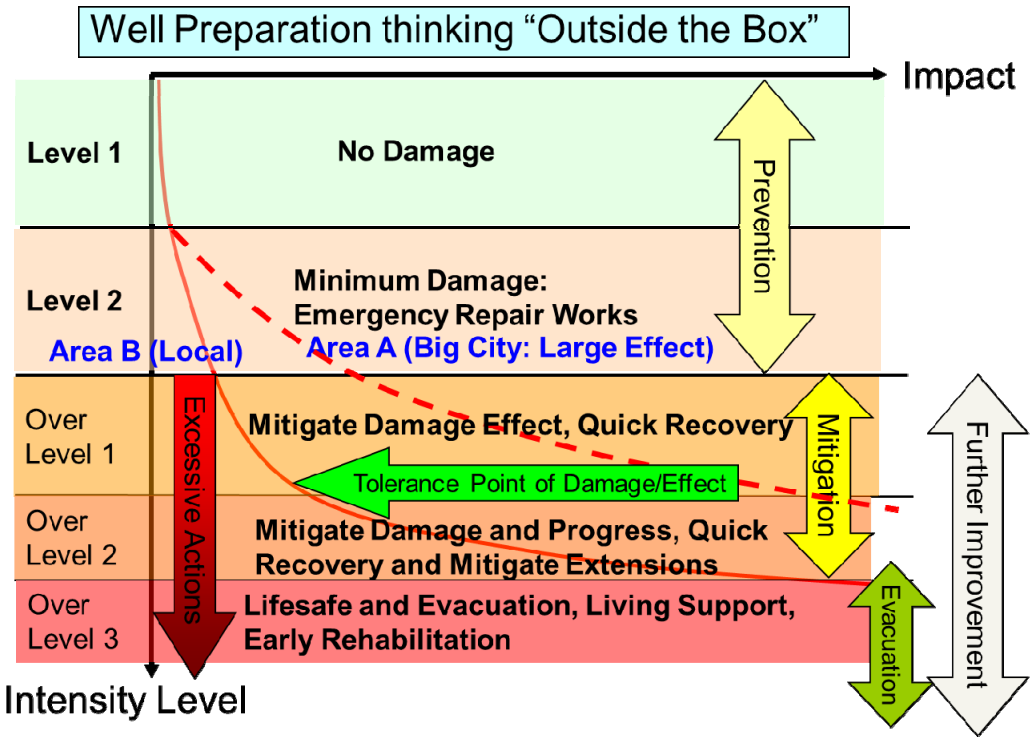

Fig. 7 Multi-level Disaster Response Concept dependent on Level of Disasters

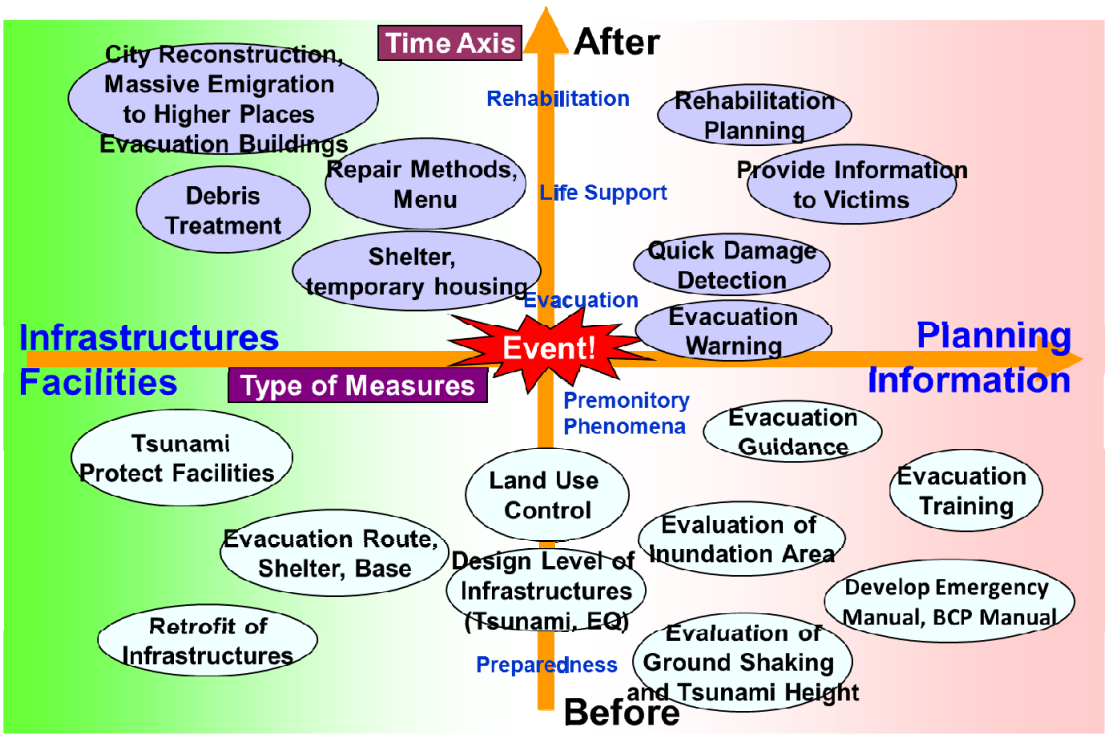

Fig. 8 Example of Countermeasures: Every Possible Effort based on "Mitigation/Evacuation"