THE JAPAN FEDERATION
OF ENGINEERING
SOCIETIES

ARCHITECTURAL
INSTITUTE OF JAPAN

JAPAN SOCIETY OF
CIVIL ENGINEERS

THE WORLD
FEDERATION OF
ENGINEERING
ORGANZATIONS

PROCEEDINGS OF
The 7th JFES-JSCE-AIJ-WFEO JOINT INTERNATIONAL SYMPOSIUM ON DISASTER RISK MANAGEMENT

SCIENCE COUNCIL OF JAPAN

September 5, 2013
College of Industrial Technology, Nihon University,
Chiba, JAPAN

PREFACE

According to the latest Global Assessment Report on Disaster Risk reduction (GAR 2013), a new wave of urbanization is unfolding in hazard-exposed countries and with it, new opportunities for innovative engineering approaches emerge. In India alone, the urban population is expected to grow from 379 million in 2010 to 606 million in 2030 and 875 million in 2050.

Disaster risk management is the key to shift a rapid development society from a high risk low sustainability cycle to a low risk high sustainability cycle. The means of such transformation include innovative engineering schemes and multi-disciplinary approaches. It will be increasingly important to reinforce mutual collaboration between architectural and civil engineering societies to reduce risk of natural hazards.

The 7th International Symposium on Disaster Risk Management is a joint effort of is expected by organizing it as a joint effort of the Architectural Institute of Japan (AIJ) and Japan Society of Civil Engineers (JSCE) with support of World Federation of Engineering Organizations (WFEO) through Japan Federation of Engineering Societies (JFES) and Science Council of Japan (SCJ). This symposium provides a unique opportunity for information exchange on new challenges and discussion on the state-of-the-art of engineering approaches for disaster risk management. I am very grateful to the efforts of the organizers for planning and organizing this Symposium to follow and expand the objectives of the past Joint International Symposium.

It is my hope that the results of this Symposium will be utilized for improving resilience against disasters in every region in the world. Making contribution to the society is one of primary role of engineers and of WFEO, and towards this aim, WFEO will keep working with partner organizations for improving engineering solutions and practices in the area of disaster risk management.

Adel Al Kharafi
President World Federation of Engineering Organizations (WFEO)

FOREWORD

Disaster damages are increasing due to urbanization, along with population growth in disaster prone areas (e.g. floodplain and coastal area), land use changes, potential climate change and a rise in sea levels. The number of people vulnerable to devastating disasters is expected to rise in urban area.

In order to secure sustainable economic development, safety should be provided not only for human lives but also for their properties in living areas via disaster risk management. To reduce disaster risk, an integrated approach is necessary among players and means. Trans-disciplinary and multi-sectorial integration and alliances are the keys. The challenge of integration is further exacerbated by the lack of a clear understanding of how the impact of development, the magnitude of hazards, and the shortage of resources and political will. In any success stories of disaster reduction, there are success stories in integration, not necessarily formal organizational integration of administrative sectors, but rather substantive cooperation on planning and implementation.

Engineers in different filed assume a key role in this challenge and there is high expectation for mutual cooperation between architectural societies and civil engineering societies. As it had always been, the 7h Joint International Symposium will also serve as a significant opportunity where engineers in the area of disaster risk management exchange their experience and knowledge vigorously.

The Joint International Symposium on Disaster Risk Management which had been held with support of World Federation of Engineering Organizations (WFEO) and its member organization Japan Federation of Engineering Societies (JFES) in six consecutive years from 2007, explored new approach to hold this event with Architectural Institute of Japan (AIJ) as a joint organizer along with Japan Society of Civil Engineers (JSCE), with the aim of providing further insights to discussions on multi-disciplinary issues.

I would like to take this occasion to express my sincere gratitude for the joint organizer and support organizations, JSCE, WFEO, AIJ and SCJ, for their cooperation in planning and organizing this Symposium. I would also like to extend my deepest appreciation for the lecturers, participants, and all other parties concerned for their support in making this Symposium successful.

柘植綾夫

Ayao TSUGE
President,
Japan Federation of Engineering Societies (JFES)

FOREWORD

I am extremely pleased to make some remarks upon the holding of the 7th JFES-JSCE-AIJ-WFEO Joint International Symposium on Disaster Risk Management.

Two and a half years have passed since the Great East Japan Earthquake (March 11, 2013). Although 300,000 people must still live in temporary housing, finally some signs of restoration from the earthquake disaster can be seen with the start of construction work for raising the level of sites, the building of public housing for those affected by the earthquake disaster, and so on. Since the disaster, support activities for reconstruction have been carried out in various locations, and institutions have undertaken surveying and research regarding the disaster. It is expected that these activities and research results will be taken into account for disaster prevention related to major earthquakes estimated to occur directly below the Tokyo metropolitan area and in the areas along the Pacific Ocean near the Nankai Trough.

On the other hand, the Fourth Assessment Report of the IPCC (Intergovernmental Panel for Climate Change) indicates it is highly likely that the increase of CO2 is due to the growth of human activities and that the CO2 emission rate should be controlled as much as possible in order to mitigate climate change. In recent years, torrential rains, heavy snowfalls and tornados, possibly caused by climate change, have been occurring frequently all over the world and causing major human suffering from floods, landslides and collapsed buildings.

In view of the recent natural disasters in Japan and the rest of the world, the theme of this symposium and the lecture content are very fitting and well-timed. I wish to express my appreciation to the Chair, Dr. Yumio Ishii, and the committee members for their hard work in holding the symposium. I would also like to express my gratitude that AIJ can contribute to the symposium as a co-organizing body.

In closing, I would like to wish for the successful conclusion of the symposium.

吉野 博

Hiroshi YOSHINO
President, Architectural Institute of Japan (AIJ)

FOREWORD

It is a great pleasure and honor for me to be given the opportunity to extend my warm welcome to all guests to the 7th JFES-JSCE-AIJ-WFEO Joint Symposium on Disaster Risk Management. Also I would like to express my heartfelt thanks to all who have spent much time and effort to organize this event.

Numerous natural disasters s occurs almost anywhere around the world at any time, making serious damages to peopleôs daily life, and even impact on the future of country. Earthquakes and tsunamis induced from crustal deformations, volcanic activities, strong winds, and landslides caused by heavy rains and floods are some of those disasters. Global warming and climate change have been contributing to the increased frequency and intensity of natural disasters.

A 9.0 magnitude earthquake off the Pacific coast of Tohoku occurred on March 11, 2011, inducing many aftershocks and large-scale tsunami. Its impact not only made serious damages to the Tohoku region, but also triggered nuclear accident at the same time.

Soon after the earthquake JSCE has entered afflicted areas, conducted several disaster assessments, and offered technical advice, suggestions and proposals of disaster recovery and reconstructions responding to the needs of those areas. For example, the Society has proposed 6 recovery reconstruction plans which place a focus on ensuring the safety of residents, rebuilding the residentsô lives and revitalizing local industries, taking into account the situations of afflicted areas. Those plans should be the basis for recovery and reconstruction of affected areas, and will modify to meet the needs of the residents. JSCE also is making proposing consensus building approaches and methods.

Moreover, the Society has analyzed reasons for the nuclear accident and made advice and proposals for improving nuclear power plantôs anti-catastrophe from a civil engineering viewpoint. It also has made recommendations on the temporary storage of radioactive waste, the selection of interim storage sites and design of storage facilities.

Scientists say meanwhile that there is a high percent chance that large-scale earthquakes will occur in Nankai Trough or directly under the Tokyo Metropolitan area. In order to minimize the risks and damages of those anticipated earthquakes, the government is implementing national initiatives and developing a national plan to build a disaster-resilience society. The JSCE, in response to the government, has set up a task-force on ñReview of safety measures to build a disaster-resilient nationò in all of 8 sections and been developing its disaster preparedness and mitigation measures.

I hope that the participants from around the country and abroad will share their experiences, ideas, and views with each other and gain something useful to further their researches and contribute to natural disaster preparedness emergency response plans back home.

Last, but not least, I would like to express my most sincere thanks to all those who have spent much time and effort to hold this significant event.

Thank you very much.

橋本鋼太郎

Kotaro Hashimoto, Exec. Pro. C.E.
President, Japan Society of Civil Engineers (JSCE)

FOREWORD

The impacts of natural hazards continue to increase around the world; the frequency of recorded disasters affecting communities has risen significantly over the past century. Hundreds of thousands of people are killed and millions injured, affected or displaced each year because of disasters, and the amount of property damage has been doubling every seven years on average over the past 40 years. Although earthquakes and tsunamis can have horrific impacts, most disaster losses stem from climate-related hazards such as hurricanes, cyclones, other major storms, floods, landslides, wildfires, heat waves and droughts. Current evidence demonstrates that changes in the global climate will continue to affect the frequency and severity of climate-related hazards.

At the World Conference on Disaster Reduction held in Kobe, Hyogo, Japan on 18ï22 January 2005, 168 governments agreed on the ñHyogo Framework for Action 2005ï2015: Building the resilience of nations and communities to disasters (HFA)ò as their common target for disaster risk reduction, which has since acted as a guideline for disaster risk reduction in the world, especially at the national level. The experiences were reviewed in the mid-term assessment in 2010 and some discrepancies and shortfall were identified.

Unfortunately, there is a great gap in current research and engineering approaches on how science is used to shape social and political decision-making in the context of hazards and disasters. Addressing this problem requires an approach that integrates research across all hazards, disciplines and geographic regions. The Science Council of Japan (SCJ) endeavors to bring together the civil and architectural engineers in a coordinated effort to reduce the risks associated with natural hazards.

The Science Council of Japan (SCJ) has been actively participating in activities of the World Federation of Engineering Organizations (WFEO) as a national member since 1972, in corporation with the Japan Federation of Engineering Societies (JFES). WFEO established the Task Group on Disaster Risk Management following a proposal made by Japan in 2007, and subsequently raised the status to the standing committee in 2009. Since then, it has been making concerted efforts with the Architectural Institute of Japan (AIJ) and the Japan Society of Civil Engineers (JSCE) in organizing this Joint International Symposium on Disaster Risk Management, which marks the seventh in this year. Recognizing the significance of holding the International Symposium on a consecutive basis, we would like to express our sincere gratitude for the efforts of parties concerned.

The Great East Japan Earthquake and Tsunami of 11 March 2011 revealed that events might happened beyond the realm of assumptions that has been considered in disaster management planning. It is recognized that the components of socio-economic activities are increasingly dependent upon each other and the impact of local disasters may quickly extend to national, regional and global scales through the market network (e.g. supply chains). There is a critical need to evaluate, comprehend and address the complexity of existing and future socio-economic systems. As societal vulnerability to disasters increases through economic development and globalization, It is a violation of the law of living with nature to establish limits related to extreme events and, thus, neglect the potential occurrence of events that might exceed those limits.

The WFEO-DRM Committee has been discussing issues of disaster risk management where members share knowledge gained from success and failure of real experience of disaster risk management experts. From this experience, we learned that natural disasters are social phenomena triggered from natural phenomena, and therefore, measures to mitigate disasters should incorporate a social approach.

Engineers should bear in mind that it is now necessary to prepare for potential events that exceed expectations. The theoretical maxim of combined multi-hazard effects must be considered in community, national and regional risk management. Catastrophic damages that may result from typhoons, earthquakes, tsunamis, storm surges, volcanic eruptions and other extreme events should be fully incorporated into the disaster risk management.

We trust this Joint International Symposium will provide a unique opportunity for networking and information sharing to those who work in affected areas, and who engage in disaster risk management in the world.

池田駿介

Syunsuke IKEDA
Chair, National Committee of WFEO
Science Council of Japan
Vice Chair, Committee on Disaster Risk Management, WFEO

石井弓夫

Yumio ISHII
Director and Chair of International Activities Committee
Japan Federation of Engineering Societies
Chair, Committee on Disaster Risk Management, WFEO

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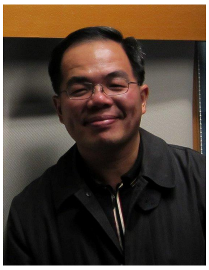
The 7th JFES-JSCE-AIJ-WFEO Joint International Symposium on Disaster Risk Management

Thursday, 5th September 2013, Nihon University

Session Part I (9:10 am ï 10:40 am)

I-1 ***Recent Developments of Runoff Analysis and Disaster Reduction against Guerrilla Rainfall and Line Shaped Rain Bands***
Tadashi YAMADA
Professor, Chuo University
Japan Society of Civil Engineers (JSCE)

I-2 ***Compound Strategy Forward to Compound Disaster Mitigation: Lessons from Hsiaolin Village, Typhoon Morakot 2009***
Wen-Chi LAI
Senior researcher, National Cheng-Kung University in Taiwan
Invited Overseas Speaker



I-3 ***Critical Engineering Needs toward Resilient Society: Collapse Quantification and Prompt Condition Assessment***.
Masayoshi NAKASHIMA
Professor, Kyoto University
Architectural Institute of Japan (AIJ)

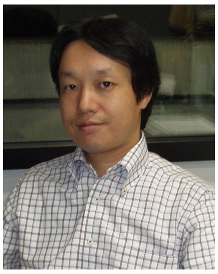
I-4 ***Reconstruction Plans and Planning Process After the Great East Japan Earthquake***
Michio UBAURA
Associate Professor, Tohoku University
Architectural Institute of Japan (AIJ)

Session Part II (10:45 am - 11:55 am)

II-1 ***Transboundary Disaster Risk Management: Coping with Large-Scale Natural Hazards with Regional Impact***
Ali CHAVOSHIAN
Assistant Professor, Iran University of Science and Technology in Iran
Invited Overseas Speaker

II-2 ***Estimation of Water Disaster Damages after Climate Change and An Adaptation Concept in Japan***

So KAZAMA
Professor, Tohoku University
Japan Society of Civil Engineers（JSCE）



II-3 ***Outline of DR^{2}AD Model (Disaster Risk Reduction investment Accounts for Development Model)***

Kimio TAKEYA
Visiting Senior Advisor
Japan International Cooperation Agency (JICA)

II-4 ***Shifting Framework from Disaster Management to Disaster Risk Management: Features in the Philippine D.R.R.M. Act of 2010 and its I.R.R.***

Benito M. PACHECO
Professor, University of the Philippines Diliman in Philippines
Invited Overseas Speaker

COMPOUND STRATEGY FORWARD TO COMPOUND DISASTER MITIGATION: LESSON FROM HSIAOLIN VILLAGE, TYPHOON MORAKOT 2009

LAI Wen-Chi and **SHIEH Chjeng-Lun**

Disaster Prevention Research Center, National Cheng Kung University, Taiwan

Abstract: In 2009 typhoon Morakot with copious amounts of rainfall struck Taiwan and caused catastrophic disasters. Different disasters including flood, landslides, landslide dams and debris flow occurred in Hsiaolin Village. The extreme rainfall has changed the disaster type, from ñsingleò type such as flood or debris flow into ñcompoundò type. The so called ñcompound disasterò is defined as a disaster by which floods or sediment-related disasters of a large extent occur simultaneously or consecutively in an event at a site. What happened in Hsiaolin Village is a significant example. It challenges the present warning, forecasting and response system of debris flow. New concept and new procedure are necessary to cope with the compound disasters triggered by extreme heavy rainfall. The rainfall hydrograph shows long-duration, high-intensity, high-accumulation and large-extent characteristics. It suggests the correlation of each disaster type with the rainfall characteristics by reference to the report of eyewitness memory. The causality between those in Hsiaolin Village occurred disasters could then be deduced. In order to characterize the disaster and suggest a strategy, it is necessary to try to rebuild the temporal order and spatial distribution of the disaster processes.

This paper describes briefly each single disaster, the relationship among those disasters and the approach to rebuild the disaster process by field investigation, topographic survey, sediment core analysis, experiments, numerical simulation and satellite image processing. The results serve to intensify the disaster prevention system of debris flow and shallow landslide which then could be applied to the warning system of deep-seated landslide and landslide dam. The derivative issues and the approach to compound disaster prevention are suggested. The related discussions, evaluation and assessment are also summarized as the reference of further tasks.

Key words: compound disaster, Typhoon Morakot

1. INTRODUCTION

1.1 Background

Typhoon Morakot struck Taiwan on 8 August 2009. Under the strong influence of southwesterly monsoon wind, Typhoon Morakot brought a record-breaking rain over Taiwan and caused catastrophic damages due its characteristic of long duration and high intensity. The extreme rainfall has changed the disaster type, from ñsingleò type such as flood or debris flow into ñcompoundò type. The so called ñcompound disasterò is defined as a disaster by which floods or sediment-related disasters of a large extent occur simultaneously or consecutively in an event at a site. What happened in Hsiaolin Village is a significant example (figure 1). Different disasters including flood, landslides, landslide dams and debris flow occurred in Hsiaolin Village.

The Jiasian metrological station registered an accumulated rain amount of 1,911 mm (figure 2) and a maximal intensity of 94.5 mm/hr. Sediment mass due to triggered slope collapse blocked Chishan River and formed a natural dam. The continuously heavy rainfall leads finally to dam break. The village was flooded by sediment flow, leaving 398 people dead or missing.

The extreme rainfall has changed the disaster type, from ñsingleò type such as flood or debris flow into ñcompoundò type. It challenges the present warning, forecasting and response system of debris flow.

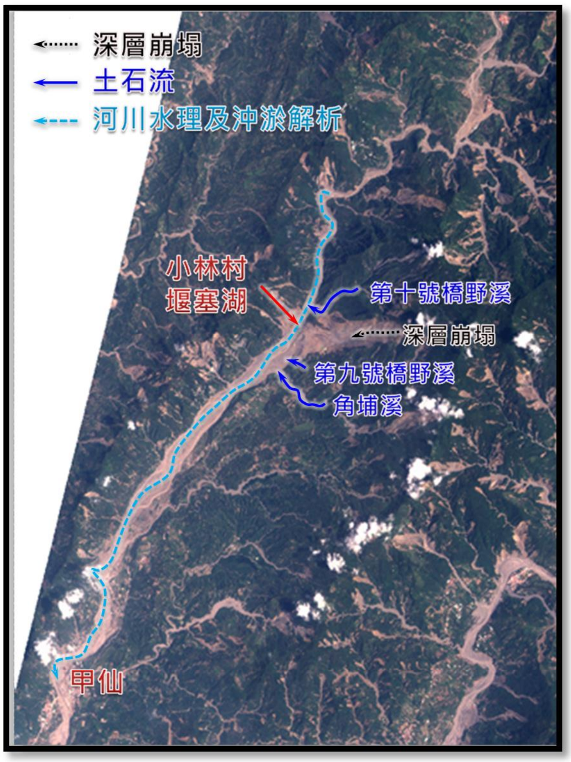


Figure 1. Location map of Hsiaolin Village

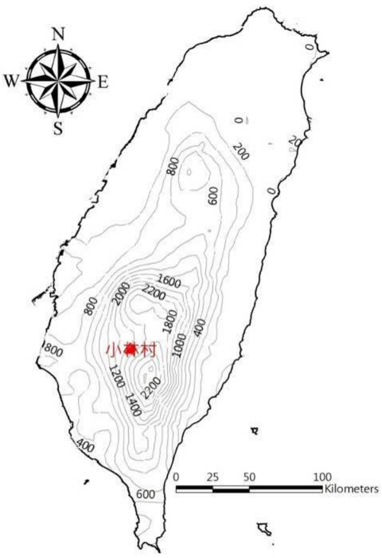


Figure 2. Distribution of accumulated rainfall by Typhoon Morakot

1.2 Objectives

New concept and new procedure are necessary to cope with the compound disasters triggered by extreme heavy rainfall. The rainfall hydrograph suggests the correlation of each disaster type with the rainfall characteristics by reference to the report of eyewitness memory. The causality between those in Hsiaolin Village occurred disasters could then be deduced. In order to characterize the disaster and suggest a strategy, it is necessary to try to rebuild the temporal order and spatial distribution of the disaster processes. This paper describes the approach to rebuild the disaster process.

2. METHODOLOGY

On the base of the results of field survey, numerical simulations were carried out to describe the sediment transport by Typhoon Morakot at Hsiaolin Village. Then the temporal and spatial order of the processes could be reconstructed. The study frame is shown in figure 3 and depicted briefly below.

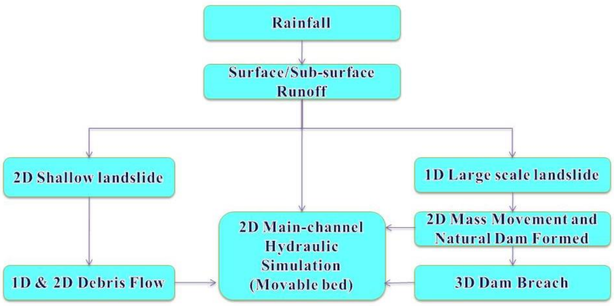


Figure 3. Study frame of the simulation

The characteristic of the rainfall by Typhoon Morakot has significance influences on the whole event. The rainfall-runoff process was simulated firstly to analyze its effect on infiltration. Simulation results provide the input information for landslide analysis. Results of landslide analysis are necessary to simulate debris flow because landslide is the main mechanism of sediment yield. Collapsed sediment could also block the flow to form natural dam. Landslide analysis is the initial step for further simulation of dam formation and dam break. The correlations of each analysis procedure are illustrated in figure 4.

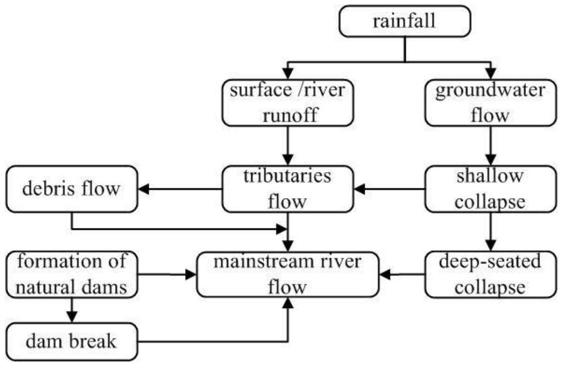


Figure 4. Illustration of components and interfaces for compound disaster analysis

3. CHARACTERISTICS OF THE RAINFALL WHILE TYPHOON MORAKOT

According to the recorded data of metrological stations, the rainfall hydrograph of Typhoon Morakot hat characteristics of high intensity, long duration, broad extent and large amount (figure 5 and 6). The figures show that the rainfall intensity of Typhoon Morakot remained high for 91 hours. The phenomena could explain the increase of landslide area of 36,000 ha, sediment yield of more than 1,000 million cubic meters and 14 natural dams. Showing the eyewitness report and rainfall hydrograph together (figure 7) a close correlation between the rainfall and each process is suggested. The preliminary reconstruction of the event serves as the base for further analysis and validation of numerical simulations.

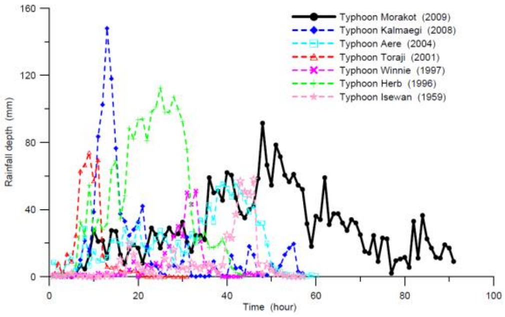


Figure 5. Accumulate rainfall depth of selected typhoons

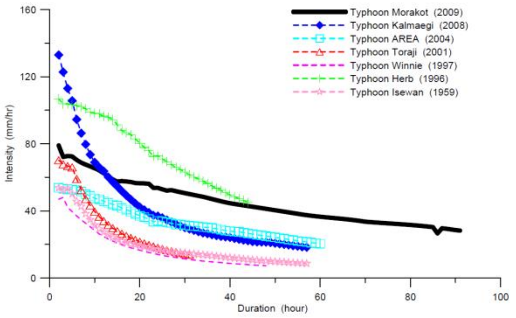


Figure 6. Intensity-duration curves of the selected typhoons

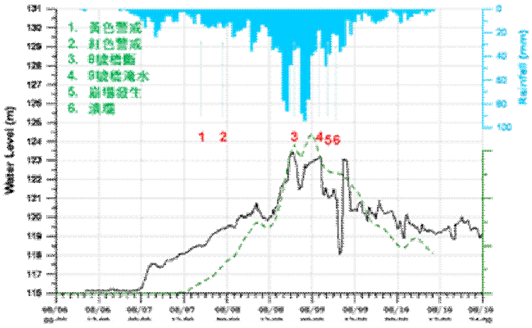


Figure 7. A preliminary reconstruction of the event

4. SIMULATION RESULTS AND DISCUSSION

4.1 Shallow landslide

Simulation of shallow landslide provides the sediment yield as initial condition for debris flow calculation and morphological change of river bed. Infinite slope method was applied to determine the landslide site and collapse depth.

The analysis area is shown in figure 8. The area was divided into 31 units with a size of 100 m × 50 m. Coefficients are determined by satellite image processing, field survey and soil material test.

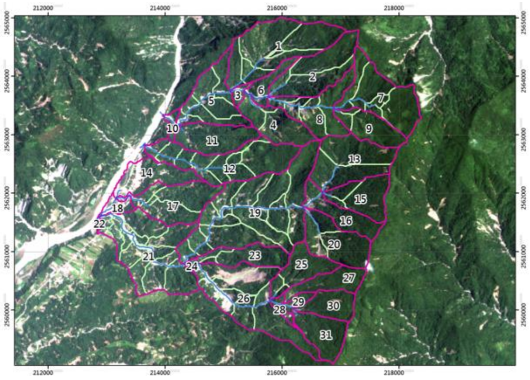


Figure 8. analysis area of shallow landslide

New landslide area is about 122 ha totally. That leads to a sediment yield of 3.8 million cubic meters. If the safety factor (SF) is defined as the ration of resistant force to drive force, then the distribution of landslide sites and safety factors in the survey area are illustrated in figure 9. The green color marked the landslide area. The change of the calculated safety factor suggest the time when landslide occurred. A landslide occurs if SF < 1 (ref. figure 10).

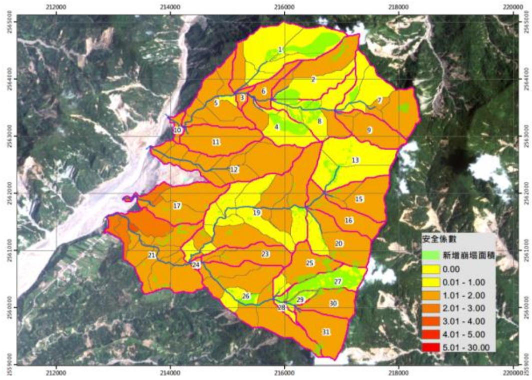
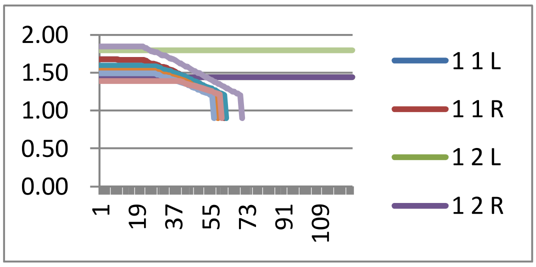


Figure 9. Analysis area of shallow landslide



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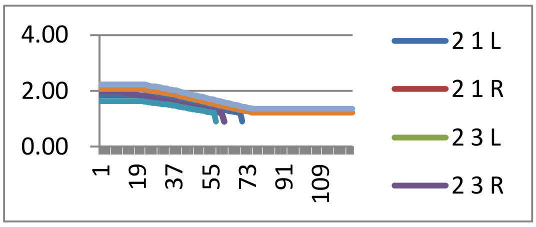
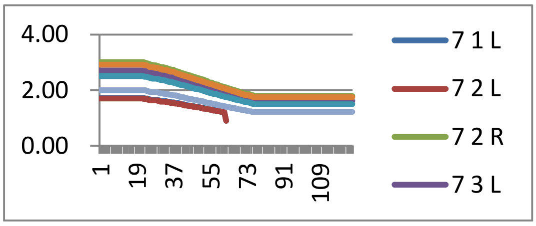


(b) unit no. 2 and 4



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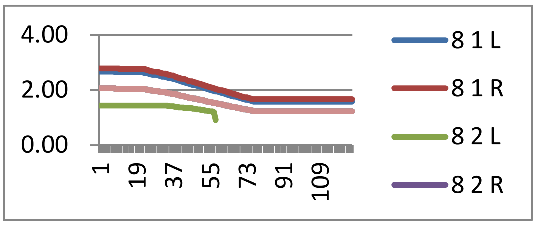

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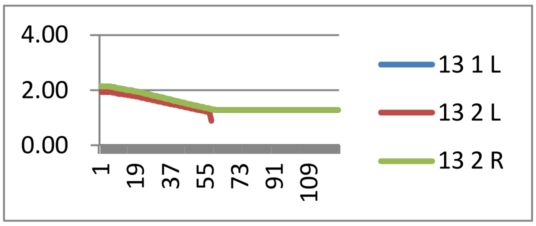

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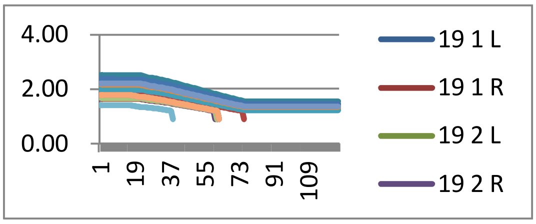

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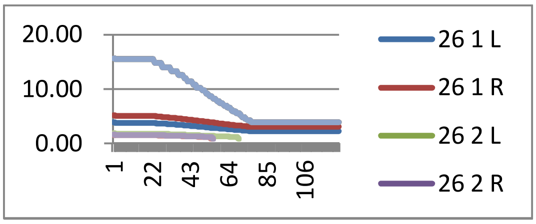

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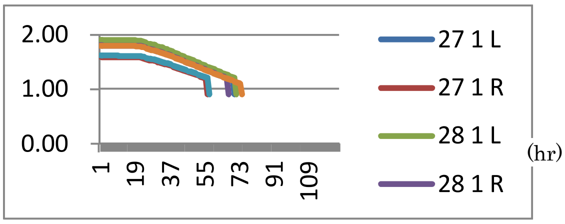

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Figure 10. Temporal change of safety factors

4.2 Debris flow

A Debris-2D model was used to simulate sediment erosion/ deposition of debris flow process to assess its impact area and change of river bed.

There are 4 debris flows in the survey area: creek at bridge no. 10, creek at bridge no. 10, Kaohsiung County DF006 and Kaohsiung County DF007 (figure 11). The sediment deposition fan were identified by making a comparison between the satellite image before and after Typhoon Morakot (figure 11 and 12). Then the related data were collected by evaluating 5m ×5m DTM, investigation and morphological survey including to calibrate the 2-d numerical model. Numerical simulations were carried out by using the calibrated Debris-2D model. The calculated changes of river bed of the 4 debris flows are shown in figure 13.

The simulation results are approximated to the survey results and eyewitness report. It also suggests that the debris flow was a continuous process by Typhoon Morakot.

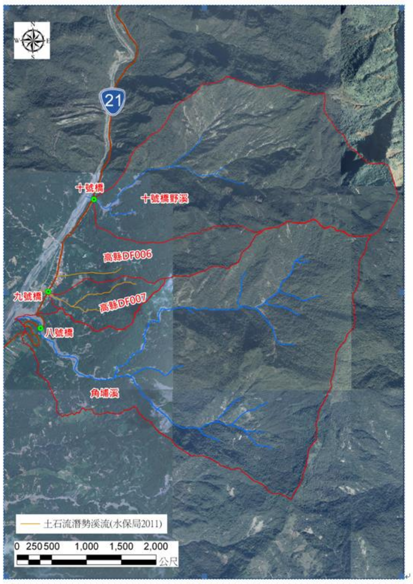
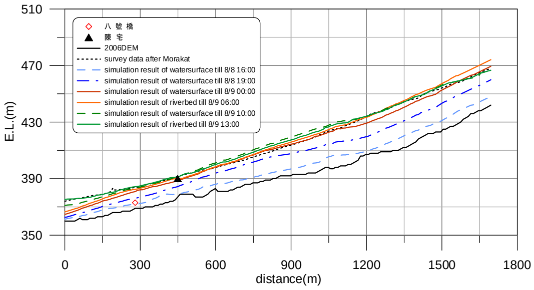
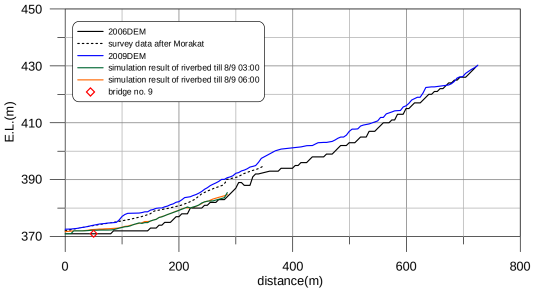


Figure 11. Location of debris flows in the surveyed area (before Typhoon Morakot)

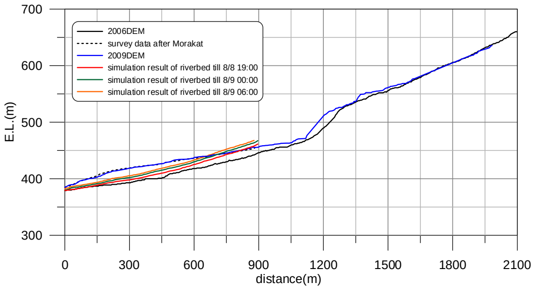
Figure 12. The stand of debris flows after Typhoon Morakot



(a) bridge no. 8



(b) Kaohsiung County DF007



(c) bridge no. 10

Figure 13. Simulation results of river bed changes

4.3 Natural dam

There were some natural dams formed by Typhoon Morakot (ref. figure 14). The dam break analysis was done by using PLAXIS model in combination with PLAXFLOW model. The coefficients for calculation are determined by satellite image processing (ref. figure 15), profile survey and soil material test. The simulated erosion process is shown in figure 16. According to the results, the storage capacity was full in 70-80 minutes after the dam was formed, and overflow occurred 70 minutes after the formation of the dam.

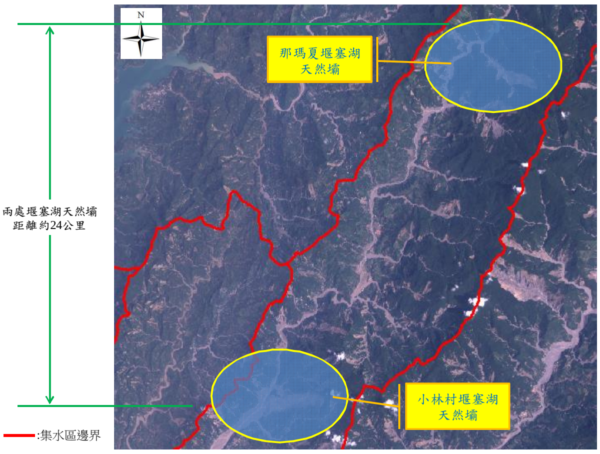
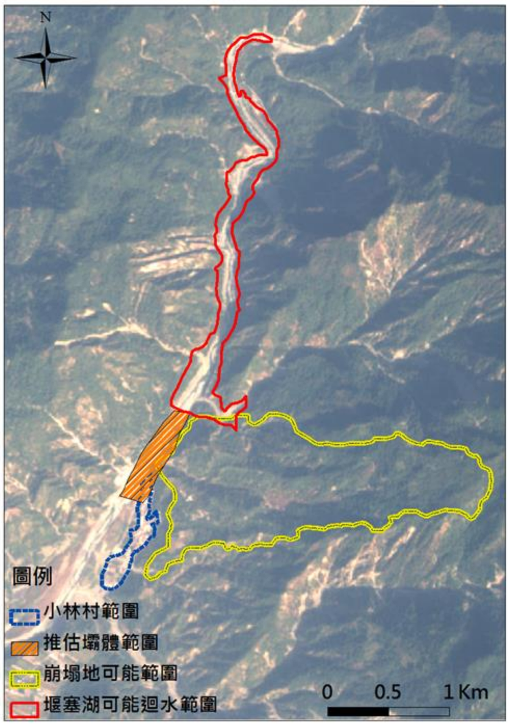
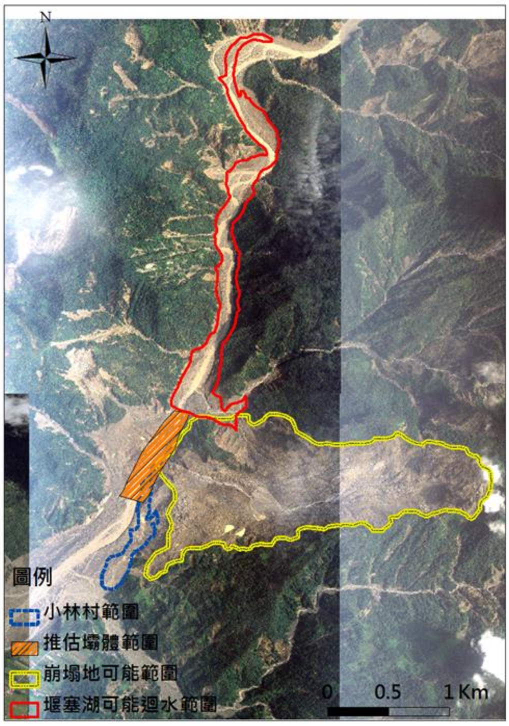


Figure 14. The natural dams at Chishan River



(a) Satellite image for analysis of natural dam (before Typhoon Morakot)



(b) Satellite image for analysis of natural dam (after Typhoon Morakot)

Figure 15. Analysis figures of the investigated natural dam.

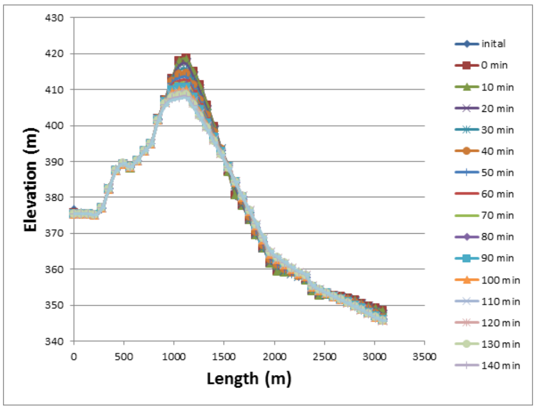


Figure 16. Simulated erosion process of the natural dam

5. CONCLUSION

The event of Typhoon Morakot at Hsiaolin village is reconstructed by using the available reports and collected data. The disaster process and the occurrence mechanism are analyzed. The results could serve to improve the disaster response capability and warning and monitoring of compound disasters. It reveals that insufficiency of the present warning system and evacuation system. A strategy draft was suggested in figure 17.

The subsequent regular inspection of the implementation of the strategy is the key to successfully manage the disasters. The derivative issues and the approach to compound disaster prevention are suggested. The results of related discussions, evaluation and assessment are also summarized as the reference of further tasks. The experiences, research results and new technologies of other countries are also collected and introduced through cooperation, publication and attending international conferences.

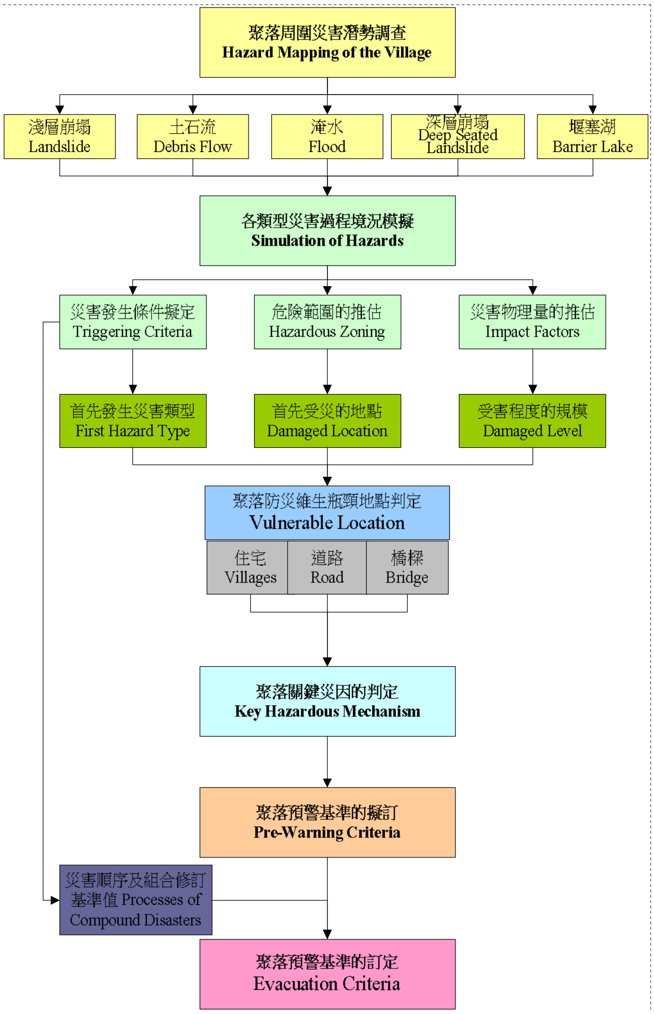


Figure 17. Guide scheme to cope with compound disasters

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CRITICAL ENGINEERING NEEDS TOWARD RESILIENT SOCIETY: COLLPASE QUANTIFICATION AND PROMPT CONDITION ASSESSMENT

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Abstract : As lessons learned from the 2011 March 11th Tohoku Earthquake, the following two themes have been identified as critical subjects to explore in earthquake engineering, namely, (1) response to earthquakes beyond what is considered in structural design and (2) continuing business and prompt recovery. To carry out research to this end, those themes must be translated into specific engineering research subjects, and they are identified as: (A) Quantification of collapse margin of buildings and (B) Monitoring and prompt condition assessment of buildings. To comply with these specific research needs, a new, comprehensive research project, entitled ñMaintenance and Recovery of Functionality in Urban Infrastructuresò, has been initiated in Japan. This article overviews the project and expected outcome.

Key words : 2011 Tohoku earthquake, Collapse margin, Structural health monitoring, Shaking table test

1 GENERAL INFORMATION

The March 11th, 2011 Tohoku earthquake, hit the North-Eastern of Japan and caused extremely serious damage. The huge damage and disruption, which mainly caused from tsunami, displays a range of engineering and social organization deficiencies. Although historical records were available, an event of this magnitude was not predicted. The earthquake resulted from an extremely large rupture, over four hundred kilometers long, was large enough to seriously alter the Japanese topography and caused a major tsunami. The tsunami caused complete devastation of many towns and villages and large loss of life over seven hundred kilometers of coast line. Damage and deaths from tsunamis were much greater than those from the earthquake shaking. Major problems occurred due to the loss of utilities after the disaster. First, several major observations of the 2011 Tohoku Earthquake are presented in this paper. Second, some lessons that were learned from the 2011 Tohoku earthquakes are described on several aspects. Details on the damage of the earthquakes are available in many publishes, for example, EERI (2013).

To face the future earthquakes, which might be greater than any past earthquakes, and to build a safer and more secure environment to live, earthquake engineering now is facing many challenges of research to comply with those observations and the lessons we learned from the past earthquakes. Among those, two key themes, one is the response to earthquakes beyond what is considered in structural design, and the other is to achieve continuing business and prompt recovery to realize resilient cities, are considered to be the most urgent for research. To carry out research to this end, those themes can be translated into two specific engineering research subjects, which include quantification of collapse margins of buildings, and monitoring and prompt condition assessment of buildings through the technologies of enhanced structural health monitoring.

Based upon the lessons learned from 2011 Tohoku earthquake, a new, comprehensive research project, entitled ñSpecial project for reducing vulnerability for urban mega earthquake disastersò, has been initiated in Japan for minimizing loss of urban disasters against large ocean ridge earthquakes along Nankai Trough and near fault earthquakes. To carry out this research, a trans-disciplinary research team has been formed, consisting of earth science, structural engineering, and social sciences. The special project consists of three components, and one of them focuses primarily on engineering issues and looks into the two themes introduced above. In what follows, presented is the outline of this component of research project.

2 A NEW PROJECT ON COLLAPSE QUANTIFICATION AND PROMPT CONDITION ASSESSMENT

The projected is entitled ñMaintenance and recovery of functionality in urban infrastructuresò, and is headquartered at DPRI, Kyoto University, with major participants including NIED (E-Defense) and multiple major Japanese design and construction firms. An oversight committee has also been established. The project will utilize advanced numerical simulation, health monitoring systems installed in existing infrastructure, and large-scale testing that will be conducted using large-scale testing facilities, i.e., E-Defense. The focus of the research team is on quantifying the margin between the design level and collapse of high-rise buildings and, most importantly, developing technologies effective to predict this margin through theory and numerical simulation. Also of interest is monitoring and prompt condition assessment of buildings.

Figure 1 shows the organizational structure of this project. The project comprises six research teams: (1) Collapse margin of steel high-rise buildings, (2) Collapse margin of RC buildings, (3) Monitoring for superstructures, (4) Monitoring for soil-foundation, (5) Monitoring for soil-structure interaction (SSI) systems, and (6) Observation using MeSO-net network. The objectives and scopes of respective research teams are briefly described below.

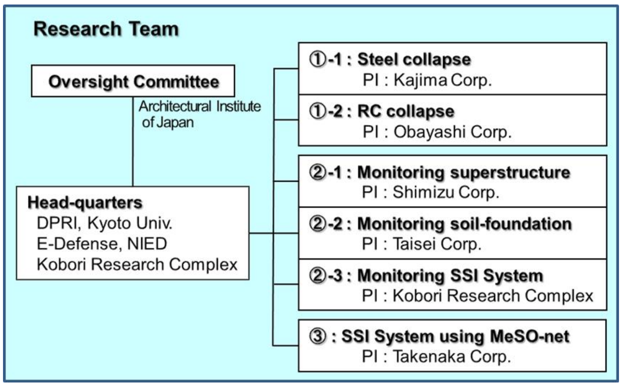

Fig.1 Organization of Project

2.1 Collapse Margin of Steel High-rise Buildings

Higher seismic performance has been particularly considered in the design and construction of steel high-rise buildings. However, in light of 2011 Tohoku earthquake and damage, the performance under extreme earthquake events and collapse margin that are beyond the design code consideration shall be quantified. A large-scale test, an eithteen-story steel moment frame building, will be tested in 2013 using E-Defense facility as illustrated in Fig. 11.

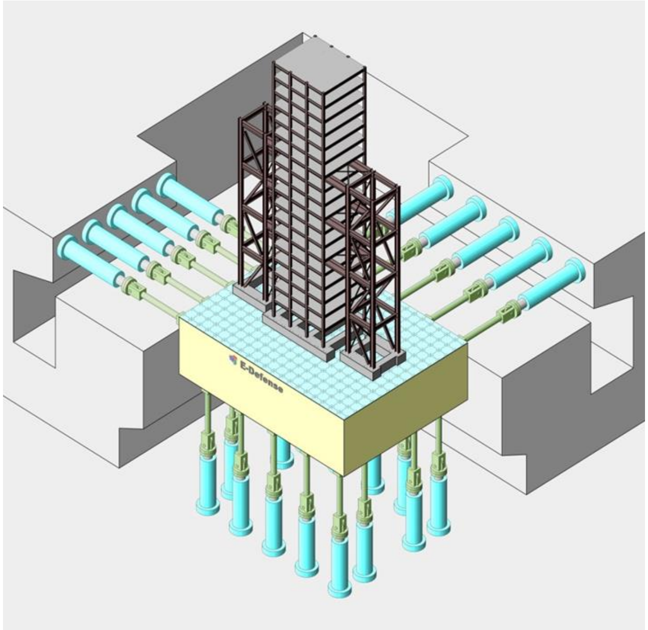

Fig.2 Eighteen Story Steel Frame for Collapse Test

2.2 Collapse Margin of RC Buildings

Many residential buildings in the urban areas adopt RC structural systems. Their seismic performance, notably under long-period and long-duration ground motions, shall be precisely evaluated, such as the characterization of the damage growth, i.e. deterioration of the structure, loss of functionality, and the quantification of collapse margin of the RC buildings. Shaking table tests are planned to perform under repeated excitation in 2014.

2.3 Monitoring for Superstructure

To rapidly ensure business continuity and prompt recovery of building serviceability, technologies related to health monitoring and condition assessment should be enhanced. Multiple subjects need to be parallelly developed and promoted, including deployment of sensors, acquisition of data, and prompt assessment on damage location for the superstructures. A series of tests on the developed technologies will be carried out in conjunction with the steel and RC building tests.

2.4 Monitoring for Soil-foundation

Prompt condition assessment for soils, foundations, and underground lifeline systems is a key for facilitating earthquake disaster responses. However, the invisibility increases the difficulty to detect the condition underground. A condition assessment system using various types of sensors deployed in the soil shall be developed. A large scale shaking table test using a sand box is planned in 2015, in which validity of the developed system will be calibrated.

2.5 Monitoring for SSI System

To assess the condition as a total system, combining the soil, foundation and superstructures, sensoring techniques that interactively combine data on superstructures, foundations, and soils shall be advanced by making use of the monitoring techniques developed for superstructure and soil-foundation mentioned above. In addition, associated condition assessment technologies shall be developed. To this end, a large scale shaking table test is placed in 2016 for the verification of the developed system.

2.6 Observation Using MeSO-net

Evaluation of structure as SSI systems shall be promoted, and to this end, realistic data that reflect the SSI system shall be collected. Use of MeSO-net system that has been deployed in metropolitan regions is most useful, and the system will be combined with seismographs that are installed in actual buildings. Continue monitoring and data analysis has been ongoing.

<END>

RECONSTRUCTION PLANS AND PLANNING PROCESS AFTER THE GREAT EAST JAPAN EARTHQUAKE

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Abstract : This paper aims at showing the numerous gaps between the ideal concept and reality in the reconstruction process after the Great East Japan Earthquake and the following tsunami within two years from the disaster. The gaps are mainly attributable to the misunderstanding or incomprehension of spatial planning by the local government, which puts too much weigh on acceleration of the planning process and lacks in preparation to deal with the disaster in the ordinary time.

Key words : the Great East Japan Earthquake, spatial planning, disaster prevention planning, reconstruction projects

1 INTRODUCTION

Two years have passed since the Great East Japan Earthquake, and it is noteworthy that most of the municipalities in the affected area had made reconstruction plans within the first year after the disaster caused by the natural calamity. Since these plans contain only general policies about the recovery from the disaster and often have abstract contents especially as for land use, the municipalities have decided to tackle the problems associated with the implementation of the plan and the related projects. However, many of them are facing difficulties and the recovery planning process is proceeding very slowly compared with those of previous disasters that have occurred in Japan, such as the Great Hanshin Earthquake in 1995 or the Niigata Prefecture Chuetsu Earthquake in 2004.

This paper aims at clarifying the reconstruction planning process and its problems by comparing the theory with the actual situation according to the following aspects; relationship between spatial planning and disaster prevention planning, necessity of additional plans on district level, importance of planning with a time perspective, citizens’ participation, and role of experts.

2 PROBLEMS OF PROVINCIAL AREA BEFORE THE DISASTER

A preliminary discussion of the general problems faced by provincial municipalities in Japan before the disaster is important, as many of the problems that occurred after the disaster can be ascribed to these issues (Fig. 1).

Two major issues are population decline and aging society. Although the Japanese population began declining since 2005, the provincial municipalities registered a declining population earlier in comparison. In Ishinomaki city, which is the municipality most affected by the Tsunami, the population declined from approximately 182,900 in 1990 to 161,600 in 2010 (Fig. 2), at a rate of approximately 12% in 20 years. On the other hand, the population of the elderly

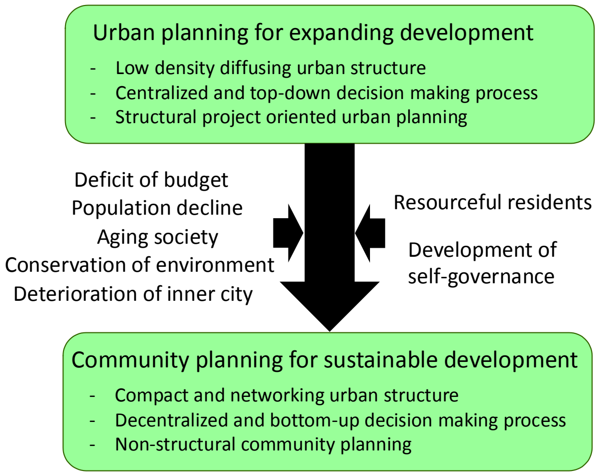

Fig. 1 Problems and future perspectives of Japanese provincial cities

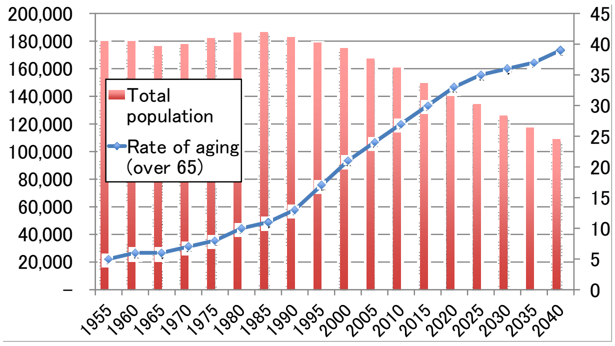

Fig. 2 Changes in Population and rate of aging in Ishinomaki city

people (i.e., over 65 years old) has been increasing from approximately 14% in 1990 to 27% in 2010. This trend is much more noticeable in the small municipalities.

Another important issue that should be mentioned is the fiscal problem of the local municipalities, as this is linked to spatial planning. The real debt expenditure burden ratio of Ishinomaki city is 14.3% in 2010, and other municipalities are also in a similar situation. Since when it exceeds 18, municipalities must obtain permission of the national government for municipal bond issue, this situation can be estimated to be severe. This also reveals the importance of a planning process that emphasizes on efficiency.

Regarding spatial planning, urban sprawl and deterioration of the inner city have been significant issues in the provincial cities. The maintenance of small settlements along the coast, where the presence of industrial depression is evident, has also caused severe problems. In recent years, additional problems occurred due to the ñreverse sprawl,ò a typical timeless, geographic phenomenon of generation of vacant lots during population decline.

Based on these premises, it is recognized that the spatial planning in Japan should change from an expanding, low density structure with a centralized top-down decision making process a sustainable and compact, networking structure with a decentralized bottom-up decision making process. However, effective solutions for these problems have not been developed yet.

3 SUMMARY OF RECONSTRUCTION PLANS

According to a general survey on the affected municipalities, the content of the reconstruction plans can be summarized as follows.

Land protection, through coastal levees, should take place against the ñlevel 1ò tsunami, occurring with frequencies in the range between once every several decades and a hundred years (ñtsunami protection levelò). Protection against the largest-scale tsunami, ñlevel 2ò tsunami, which occurs once every several hundred or more years, should be guaranteed from both structural and non-structural aspects (ñtsunami diminishing levelò). The inhabitable area is limited to an expected inundation height of less than approximately 2 m in the case of ñlevel 2ò tsunami. The area with expected inundation higher than 2 m, is designated as disaster hazard area, and its residential use is forbidden.

Reconstruction land use plans, which are made to ensure this safety level, can be categorized into five typical patterns according to the investigation of the national government [2)]:

a) ñRelocationò: part of the inundated area, with expected inundation height of more than 2 m of ñlevel 2ò tsunami, is designated as disaster hazard area, and the settlements must be relocated outside the inundated territory.
b) ñAggregation on siteò: the settlement is to be aggregated to the on-site area, where safety is ensured by a coastal levee or a secondary levee.
c) ñLand Raisingò: part of the inundated area is to be raised, and the settlement must be aggregated there.
d) ñRelocation + Land Raisingò: combination of Relocation and Land Raising
e) ñOn site reconstruction with defense facilitiesò: the inundated area must be reconstructed when the safety is ensured by structural protection facilities.

4 RELATIONSHIP BETWEEN SPATIAL PLANNING AND DISASTER PREVENTION PLANNING

4.1 Conflicts between objective and subjective safety in reconstruction plans

The height of the levee required by the local residents is in some cases lower than that, planned by the government. Moreover, the areas where residents want to live are occasionally designated as disaster hazard area, where the construction of house is forbidden. These cases occurred mainly among the fishing villages along the ria coast, where peopleôs life is closely linked to the ocean through fishing, representing both a regular vocation and a tourist industry. The planned tsunami protection system is excessive for those people, hindering their comfort and convenient daily life or smooth industrial activities and it is considered responsible for accelerating the decline of the village.

In other cases, the height of the levee required by local residents is higher than that planned by the government. Moreover, the designation of the disaster hazard area, where they can relocate with subsidies, is too narrow for those who want to live outside the area. These cases are observed mainly near or in the city, where most residents are paid workers, whose economy and lifestyle remotely relate to the ocean. They are generally afraid to take a risk of a tsunami, no matter how low it is in theory.

Both conflicts can be ascribed to the gap between objective and subjective safety, whose nature is deeply connected with the characteristics of the settlements. This conflict demonstrates the necessity of the flexible planning of the levee or the land use, especially in the case of a requested lower levee, which is not a big fiscal issue.

4.2 Ideal relationship between spatial planning and disaster prevention planning

A crucial issue in the spatial reconstruction planning process is the safety of the city or village, for the disaster, which triggered the planning, occurred for this very reason.

However, safety is not the only important factor be considered in the planning process, and it should not always be prioritized over other interests. For example, the safety level will increase if a higher levee is constructed. However, the latter will block the view of coastal landscape, thereby negatively impacting the tourist and fishery industry, which needs regular observation of sea conditions. This, in turn, represents a ñriskò of declination for the villages, whose economy is based on these industrial activities.

The same arguments applied to land use. New settlements often locate on the hills or inland, where the risk of tsunami is extremely low. However, they will be sometimes scattered due to the limited availability of hilly land for building construction, with the consequent dispersion of the communities of inhabitants, who will suffer a great discomfort in their daily life.

These example show how the construction of tsunami protection facilities or the change in land use and building relocation can bring as many advantages as disadvantages in terms of safety, comfort, amenity, efficiency, and landscape. Therefore, all these factors should be taken into account during the planning process integrating the needs of safety with all the other aforementioned aspects within a comprehensive relocation plan.

A committee of the national government, ñExploratory Committee of Countermeasures against Tsunami in the Coastal Area (*kaigan ni okeru tsunami taisaku kentou iinkai*)ò takes the similar stands: In the report of the committee, ñThe basic concept on reconstruction of coastal levee suffered from the Great East Japan Earthquake and Tsunami in 2011 (*heisei 23 nen touhoku chihou taiheiyouoki jishin oyobi tsunami ni yori hisai sita kaigan teibou touno fukkyuu ni kansuru kihonteki na kangaekata*)ò, the necessity of comprehensive planning is cited as follows; ñThe crown of the levee should be decided on the premise of the water level of planned tsunami or high tide. During the planning process, care for the diversity of coastal function, environmental protection, blending in with the landscape, economical efficiencyé should be comprehensively taken into account.ò

4.3 Actual situation

However, Miyagi prefecture, the most affected by the tsunami, persists with constructing the highest levee permitted by the fiscal legislation. It decides the height of coastal levee only by the necessity of tsunami and high tide protection, whichever is higher (1).

One of the reasons for such a policy might be the regretful will of the prefectural governor to be officially responsible for the safety of present and future generation of local residents (2). Another possible reason is the vertical administrative structure with members of the division of levee construction ñdoing their bestò with little concern for the structural and non-structural urban aspects.

5 NECESSARY INTEGRATION OF PLANS ON DISTRICT LEVEL

5.1 Project coordination on the district level

(1) Necessary adjustment of projects

The reconstruction of the settlement in the affected area occurs with different projects under the jurisdiction of different departments and agencies being planned at the same time and in the same place: road, levee, and public housing construction, land readjustment, and collective relocation projects for disaster prevention are all planned simultaneously. In this scenario, it is imperative to set the time schedule, the areas and the contents of each project on a working level that can promote all of them.

Fig. 3 Image of unified plan along Kitakami River
(Note: Urban and Regional Planning Lab., Tohoku University)

Photo. 1 Situation of Watanoha district, Ishinomaki city, two years after the disaster

(2) Elimination of waste

Many public facilities were damaged by the disaster, and most of them need to be reconstructed. Furthermore, new tsunami protection facilities are needed to guarantee the safety of citizens. Those facilities should be constructed as soon as possible and with minimum waste. Most of the recovery and new construction projects will be financed by the national government, in other words, the national taxes. These costs represent a burden on the young generation, and hence they need to be minimized. In addition, the finances from the national government should not cover the whole cost of the project, and some expenses, some of the construction cost as well as the most of the maintenance cost, should be covered by the local governments.

However, these reconstruction projects are not well coordinated and many problems arises. The following examples illustrate the barriers that hinder smooth project coordination.

One barrier is between the vertically divided administrative organizations. In Minamisanriku town, for example, the coastal levee and the mounded national road are planned to run parallel to each other, in close vicinity of about 100 m. The road, planned to be behind the levee, is even higher than the levee and the local government is planning to fill the resulting dips between the two infrastructures. Although the construction of a road that also functions as levee might present an economic advantage, it is hard to coordinate the two projects because the levee is planned by the prefectural government and the road is by the national government. Each section is overloaded with such enormous tasks that the active coordination between the two is completely neglected.

The other barrier is the time sequence. Each section of the project works with its own time schedule, which means that while one project proceeds with the construction phase, the other is still at the basic design stage. In these cases, it is almost impossible to coordinate the two projects.

(3) Contribution to creation of new attractive place

A coordination of the projects contributes not only to waste reduction, but also to creation of a new attractive space for the future generation.

In Ishinomaki city, for example, the construction of the embankment on Kitakami River is planned to take place in the central part of the city. Ishinomaki city was historically developed as a port along the river. After the disaster, the national government has planned to construct the embankment, while the prefecture is in charge of rebuilding the bridge, and the city of redeveloping the site along the river for commercial use. If those projects proceed uncoordinated, the city center will be separated from the river and will be an ordinary center.

Therefore, at the moment members of the national, prefectural and local government arrange regular ñworking-levelò meetings with academic experts and consultants to coordinate in time, space, budget and explanation of the projects to the local residents to form the area, where city and river are structurally and non-structurally closely connected with each other (Fig. 3).

5.2 Blank area of the projects

There are many projects for the requalification of the affected area such as land readjustment, urban redevelopment, and projects promoting the group relocation for disaster mitigation. All of them present several problems in the planning and implementing phases.

Furthermore, the areas severely damaged by the tsunami, for which these reconstruction projects have not been planned yet, are waiting for problems to be solved: although there is no local regulation for reconstruction of houses, most of the residents are anxious, and not willing to have their houses rebuilt in the same place as before. For this reason, this land is still vacant even two years after the disaster as is seen in Watanoha district in Ishinomaki city (Photo. 1). The situation is worsened by the indifference of the local government towards the residents, who feel abandoned, since it gives information or expenses man power and money only through concrete reconstruction projects.

Although it might be difficult to plan and implement large scale projects in those areas, there is an urgent need for the improvement of the district through implementation of small scale structural projects, such as small residential district improvement project based on Building Standard Law, or non-structural projects, such as evacuation drill and promotion of community activities.

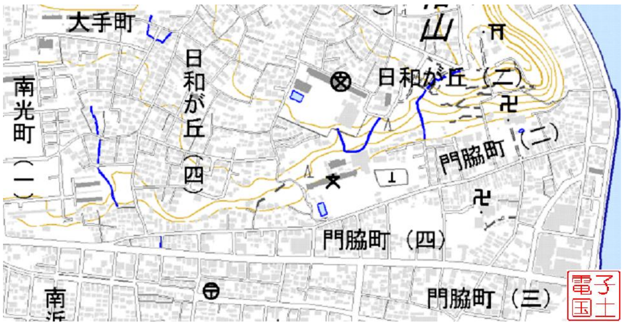

Fig. 4 Present situation of K district, I city
(Resource: 1:25,000 map by Geospatial Information Authority of Japan, no scale, no direction)

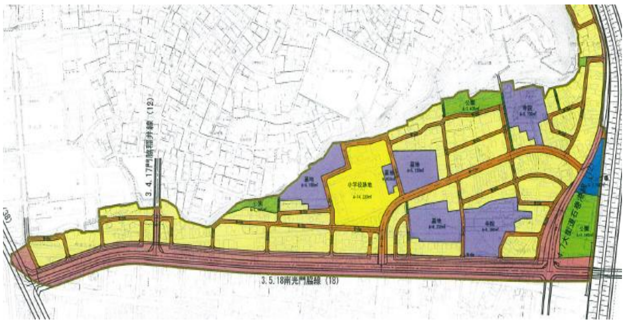

Fig. 5 Plan of land readjustment by I. city
(no scale, no direction)

6 TIME SCEQUENCE AND PLANNING

6.1 Attention to the "Past" in the planning process

Most of the buildings in these urban and rural areas were washed out by the tsunami or demolished afterward. Many of the Kura storehouses could have been conserved, but were demolished because of the high cost of reconstruction and maintenance. Even in such a situation, however, there are still many structural and non-structural infrastructures that should be saved. Considering the history and characteristics of the area, it is important to preserve these facilities for the future generations.

Roads are an example of such type of infrastructure. Particularly in the areas where land readjustment is planned, it could be a good option to preserve the pathway and width of the roads in order to maintain the original landscape. Otherwise, the new road network will be planned as a grid-like structure typical of a new suburban, residential area.

On the other hand, not everything should be restored as it used to be before the disaster. In fact, one possible reason for the decline of the settlements might have been the irregular form of the sites and the narrow roads, which were inconvenient for car users. In such cases, preserving the old style may accelerate the decline of the area.

Hence, every infrastructure should be carefully evaluated to determine what should be preserved and what to be changed.

In the present situation, however, new reconstruction is often preferred to restoration of old infrastructures, leading to standardized settlements with limited feature. In the case of Kadonowaki district in Ishinomaki city (Fig. 4), local government plan attempted, within a certain degree, to preserve the old configuration of the streets (Fig. 5). In the eastern part of the district, there could be a plan for an improvement of the territory landscape, as a long time will be required by authorities to investigate the area and for the local residents to understand the characteristics of the area and importance of it. However, this plan is hardly compatible with the needs of a prompt recovery planning process in order to measure up to the expectations of the people affected by the disaster.

6.2 Attention to the "Present" in the planning process: Ensuring quantitative and qualitative adequacy

The level of housing expectations for the affected people by the disaster varies drastically with time and conditions, and these ultimately affect both the future land use and the size of new settlements. Municipalities therefore conduct meticulous and frequent surveys about peopleôs expectations.

Many projects were planned in the chaotic and uncertain period shortly after the disaster. Some of them demonstrated that the size of the new settlements is excessive with respect to the real demand, especially in the case of on-site land readjustment projects. In Ishinomaki city, for example, this sort of projects are planned in four districts. However, most of the local residents want to sell their land and move to the inland, which is safer considering future tsunamis. Only 20 to 30 % of them want to rebuild their houses where they lived. It is thus foreseen that many lots will remain vacant after the accomplishment of the project and the improvement of the urban facilities with considerable expense. This will lead to new inefficient settlements with extremely low density of scattered houses.

New sort of project, which will solve such a problem, should have been developed before the disaster and, at least in the planning process of the project, the preferred developing areas should have been selected with a strategy of ñselective concentrationò in order to prevent useless public investment in infrastructures.

In addition to the quantitative aspects mentioned above, there are also some problems in the qualitative aspects of the planning process. An aforementioned inadequacy is the insufficient attention to the historical aspects. However, the municipal authorities do not intend to modify the contents of the plans with the excuse of the first, provisory stage that is the same plan already explained to the local residents and one which will never be modified.

Although speed is a very important factor to be considered in the reconstruction planning process, especially in the case of industrial recovery, the adequacy in the size of the settlements and their quality is sometimes underestimated.

6.3 Attention to the "Future" in the planning process

The settlements, developed by the reconstruction projects, will be likely to decline shortly after their accomplishment, as the population of the region will decrease and this trend will even accelerate because of an aging society. It is therefore important to consider the shrinkage of the population since the beginning of the planning process.

Fig. 6 Reconstruction plan of Akamae district, Miyako city
(Note: Material for explanation meeting for local residents)

From this perspective, the first step should be the development of existing sites in the undamaged settlements, as many of these sites are already witnessing a declining process with many vacant lots and houses available to host people. If a relocation site is planned out of the undamaged settlement, both new and old settlements will eventually remain with many vacant lots and houses.

Akamae district in Miyako city is a clear example of this phenomenon. Although there are many vacant lots and houses in this settlement, local government has planned new relocation site mainly distributed outside the district (Fig. 6). Several reasons for this plan were provided by the city administration, such as the unwillingness of the victims to live in the village with unaffected residents, the unwillingness of land owners to sell their land to local government, and the impossibility of expanding the narrow roads of the unaffected settlement, because it concerns many land owners and may result in complex and long-term projects.

Moreover, it is also important to consider shrinking processes in land use or architectural plans of the new settlements. One of the typical examples is the conversion from the public housing to nursing home after the residents get older. Another example can be the land use plan with consideration of use program of vacant lots before they generate.

However, the local municipalities cannot afford to consider the future implications as the target of their planning is mainly limited to the accomplishment of the project.

7 PLANNING PROCEDURE

7.1 Problems in citizen participation

(1) Introduction

In general, the municipalities in the affected area did not have experience in active citizen participation before the disaster. In the planning process of recovery plans, however, almost all municipalities organized committees composed by citizens and this is an appreciable initiative.

However, the citizen participation modality presents many difficulties.

(2) Difficulty in sharing information / gathering opinion

For an effective participation, it is necessary to share accurate information with the citizens and understand what they want.

As most of the damage was caused by the tsunami, it was difficult to construct temporary houses in the affected areas, and to find a suitable flat land in the neighboring territories. Some of the temporary houses were therefore constructed in other municipalities, located far from the affected areas. In these cases, the moving-in process was fairly managed mainly according to age criteria and through lottery, regardless the former community.

This situation was worsened by a leased public housing system: existing private rental houses were temporarily regarded as public houses and rented to the victims of the tsunami, because of the shortage of actual public housing and temporary houses in the territory. This resulted in the collapse of the community, since the affected people moved individually by household and were dispersed.

Some municipalities therefore began to inform the citizens of the reconstruction planning process not only by print media, such as public relations magazines, but also by internet or e-mail.

(3) ñSubstantial participationò and ñceremonial participationò

Citizen participation can be generally divided most simply into two kinds of participation according to the degree: ñsubstantial participationò and ñceremonial (or tokenism) participationò (3). Fundamental difference between them is, if substantial final decision has been already made or not when the participation procedure is done.

In the planning process, some municipalities or the citizens held several workshops to review multiple plans and approve the final. However, in other cases, local, prefectural and the national government held only ñexplanatory meetingsò, with a public officer explaining the final plan without the possibility of any modification.

Many municipalities engage in ñceremonial participationò based on ñexplanatory meetingsò because they are not accustomed and have no experience to make plans with citizens; also, busy schedules with consequent lack of time and manpower do not allow them to consider elaborate planning processes. On the other hand, the citizens as well rely too often only on the administrations, and ask for quick decisions without having a clear opinion on them.

An issue that has occurred with this ñtokenism participationò is the aforementioned controversy over the height of levees. Prefectural government held many ñexplanatory meetingsò to illustrate the final plan of the levees, but these did not either consider or negotiate with peopleôs views. It is inferred that such an attitude of prefectural government made the attitude of local citizens stiffened.

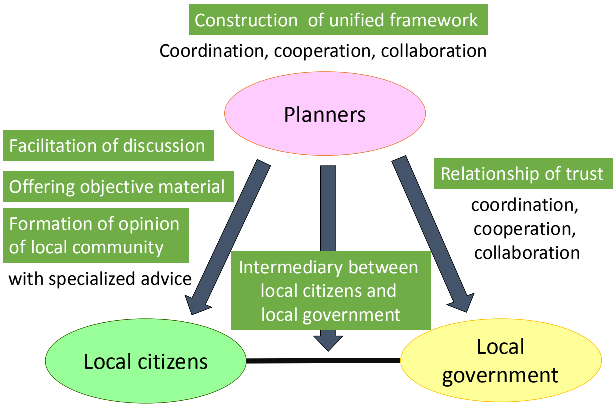

Fig. 7 Support for consensus building of local community by planners

7.2 Role of planner as an expertized coordinator

(1) Introduction

Local citizens should play an important role in the planning process especially on the district level, as the decisions in the plan have a very close impact on their daily life and activities. However, due to a lack of experience, it is difficult for them to get involved and to take an initiative in the planning process. Although administration of the local government should be urged to hold a direct dialog with them, this is not often possible because the administrative function of local government itself was damaged by the disaster. Furthermore, a direct interaction between the administration and local citizens could sometimes generate many conflicts.

Hence, a support from external planners could play helpful role. The functions of an external planner should be as follows: 1) planning and presenting of objective materials or drafts to local citizens, 2) facilitating the discussion among the local citizens to build consensus, 3) working as an intermediary between the administration and the local citizens - not only as an agent of the administration or in advocacy of the local citizens (Fig. 7).

In the present reconstruction plans, many architects, civil engineers and urban planners support a planning process that involves the citizens in a direct participation. As most of these are still ongoing plans, it is hard to estimate the efficacy of the supportersô action, and hence only a theoretical framework defining the role of planners is discussed in this article.

(2) Relationship between planners and local citizens

There are three functions of the planners in helping the community build consensus. First is the facilitation of a discussion within the community that includes planning the content and the schedule of the meetings. Second is the provision with objective, informative materials, such as forecasted population trend or future land configuration of local areas. Third is helping the local community to reach a consensus.

This third function implies two important aspects: first is the ability of listening to the citizensô opinions, and help them converge to an agreed opinion. A ñHit-and-awayò approach, i.e. presenting the erratic idea out of the real context does not help establish a confidential relationship with the local citizens. On the other hand, if the expertôs role is limited to just coordinating the ideas of the local citizens, then it is also insufficient. Second, it is therefore important to guide them in the discussion of the important issues and planning process, by giving them technical advices.

(3) Relationship between planners and local government

The plan made by the citizensô initiative should be feasible so that the contents of it should be taken into the official reconstruction plan. Hence, it is important to build a close and trustful relationship between planners and local governments for the implementation. Without this, planners might be considered a disturbing factor by the local government, and the latter, on the other hand, can be viewed as a rigid organization which refuses to include some ideas of the citizens into the plan. As a result of this controversy, the plan made by the local citizens with plannersô support will not be considered into the official plan proposed by the local governments. The largest victim in this case is the local residents, who were engaged in the planning process by making their time just in vain.

It is therefore important that planners continuously cooperate with the local governments and find a common ground on which to lead the discussion among the local citizens.

(4) Relationship between planners and other experts

Many of the reconstruction plans deal with projects that entail civil engineering and architectural aspects. Needless to say, a plan integrating land improvement and architectural works improves the quality and the attractiveness of the settlement. Furthermore, daily life realities such as educational, social welfare and commercial activities should be taken into account in the planning process for the development of a comfortable and convenient settlement.

It is therefore necessary to get involved in the discussion not only architects, civil engineers and urban planners, but also experts in education, social welfare or medicine. All these professionals should cooperate and collaborate to make efficient and effective plans for the revitalization of the settlements. A cooperative action among the experts will also avoid them to work separately and pulling the plan in different directions, which often generates confusion among the local residents.

8 CONCLUSION

This article depicts several gaps existing between the ideal concept and the reality in the reconstruction process after the Great East Japan Earthquake and the following tsunami.

Besides the misunderstanding or incomprehension of the spatial planning by the local government, some of the gaps are caused by excessive timer-related limitations in the planning process. This aspect is strongly linked to the qualitative and quantitative lack of manpower shown by the local administration despite the help of many supporting officers from all over Japan. It is important to accelerate the reconstruction work, as most of the victims hope to put their lives back together as soon as possible. In particular, industrial activities should start again soon so that people can the earn money needed for their recovery. However, this article illustrates that time limitations may also have a side effect and claims that different problems may need different plans, some that are quick and others with a more elaborate and careful processing.

Other problems originate from the inadequate dealing with the problems with firm commitment before disaster, i.e. in an ordinary time. Disaster makes the problems we had had already before the disaster much worse rapidly and drastically. Although there is a necessity to develop new planning methods that suit to todayôs trend such as population decline, shrinking settlements, promotion of active citizen participation and citizenôs autonomy both theoretically and systematically. Hence, one of the most important countermeasures for recovery from a disaster that should be taken in advance is to tackle with the present problem in ordinary time to their full extent.

ACKNOWLEDGMENT

The author would like to sincerely thank Prof. Katsuya Hirano and Prof. Yasuaki Onoda, International Research Institute of Disaster Science, Tohoku University, and many other colleagues, consultants and municipal officials for their helpful daily discussions. He would also like to thank Japan Science and Technology Agency (JST) for the financial support in the framework of ñCONCERT-Japanò.

APPENDIX

(1) http://www.pref.miyagi.jp/uploaded/attachment/43036.pdf
(2) Press conference of Miyagi prefectural governor on July 8. 2013.
(3) The former corresponds to ñinformingò, ñconsultation,ò and ñplacationò in the theory ñA Ladder of Citizen Participationò by Arnstein (1969), and the latter corresponds to ñpartnershipò and over.

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TRANSBOUNDARY DISASTER RISK MANAGEMENT: COPING WITH LARGE-SCALE NATURAL HAZARDS WITH REGIONAL IMPACT

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Abstract: Large-scale natural hazards do not respect boundaries, be they national, regional or institutional. The impacts of economic losses expand across borders worldwide. Large-scale natural hazards with huge economic damages (e.g. GEJET, 2011) dramatically demonstrated that economic impacts and losses cross borders through industrial and manufacturing supply chains, which are increasingly common in both developed and developing nations. It was a concatenation of disaster impacts from local to national, from national to worldwide. Therefore, transboundary disaster risk management is imperative, it involves both Governments as borders are involved, and their people as risk is involved. In order to implement this concept of transboundary disaster risk management, a paradigm shift is necessary from focusing on emergency aid and international response operation to risk management before disaster occurs. However, this concept is not easy to implement for transboundary disaster risk management: joint monitoring, forecasting and early warning, coordinated risk assessment and joint planning of measures, and appropriate legal and institutional frameworks are all necessary.

Key words: Regional impact, Transboundary disasters, UNECE Water Convention, UNECE Industrial Accident Convention

1 INTRODUCTION

The world-wide increase of disaster losses is an evidence of unsustainable local development as well as lack of proper transboundary disaster risk management. Global trade, financial markets and supply chains have become increasingly interconnected. When disasters occur in globally integrated economies, the impacts ripple through regional and global supply chains causing indirect losses to businesses on the other side of the globe (GAR, 2013).

In contrast to some success stories, as reduction in death tolls by flood (Fig. 1), there are still many challenges left all over the world, in particular in disaster with regional to global impacts. Other than Cyclone Nargis (2008) that fuels rice price in the international market (Chavoshian & Takeuchi, 2011), Hurricane Katrina (2005), many events were not forecast or were more extreme or of more serious transboundary impact than expected. There were reports of death tolls and casualties in more than15 countries in the case of the Indian Ocean earthquake and tsunami in 2004(Fig. 2). In 2010 and 2011 alone, the following disaster with huge transboundary impacts occurred: the Eyjafjallajökull volcanic ash cloud in Iceland in April 2010; the Great East Japan Earthquake and Tsunami (GEJET) in March 2011 and striking floods in large areas of Thailand, including Bangkok, in October and November 2011 (Jha *et al*., 2012).

Interdependence of economic activities often results in a concatenation of impacts and damage when it encounters disasters, which is unavoidable if hazards are not physically controlled. It implies that economic development requires high protection against hazards if the development site is located in a hazardous area. Early warning and evacuation or insurance do not help in stopping concatenation from happening.

Redundancy in the supply chain would help the national and international economy, but may not always be feasible in the case of high-tech products which are often manufactured in specialized, irreplaceable factories. It should not be overlooked that the occurrence of such concatenation effects are not confined among developed nations, but start from or reach to developing nations. Less developed nations receive more serious impacts. Therefore, transboundary disaster risk management is imperative. This concept is not easy to implement: joint monitoring, forecasting and early warning, coordinated risk management and planning are all necessary.

2 TRENSBUNDARY IMPACT

The impacts of the Eyjafjallajökull volcanic ash cloud in Iceland in April 2010 demonstrated how an eruption could affect business in a globalised world (Munich Re, 2010). For up to six days, air traffic in most European countries was shut down; and airlines lost US$1.7 billion in revenues. At its peak, the crisis impacted 29 percent of global aviation and affected 1.2 million passengers a day. Businesses also lost billions in uninsured losses (GAR 2013). Insurance payments are only made if business interruption is preceded by physical damage to the insured property itself or ï with extended coverage ï a supplier of parts or utility company. In this case, aircraft were not damaged; they were simply grounded.

Following the 2011 earthquake and tsunami, automobile and electrical component production in Japan declined by 48 percent and 8 percent, respectively. But automobile production also fell by 20 percent in Thailand, 18 percent in the Philippines and 6 percent in Indonesia. Electrical component production fell by 18 percent in the Philippines and 8 percent in Malaysia (Ye and Abe, 2012).

Following Tropical Storm Nock-Ten and heavy monsoon rains, the Chao Phraya River flooded in Thailand, inundating 15 provinces of the country (Haraguchi and Lall, 2012). From October to December 2011, more than 1,000 factories of 804 companies were flooded for up to two months. Of these companies, 451 were Japanese.

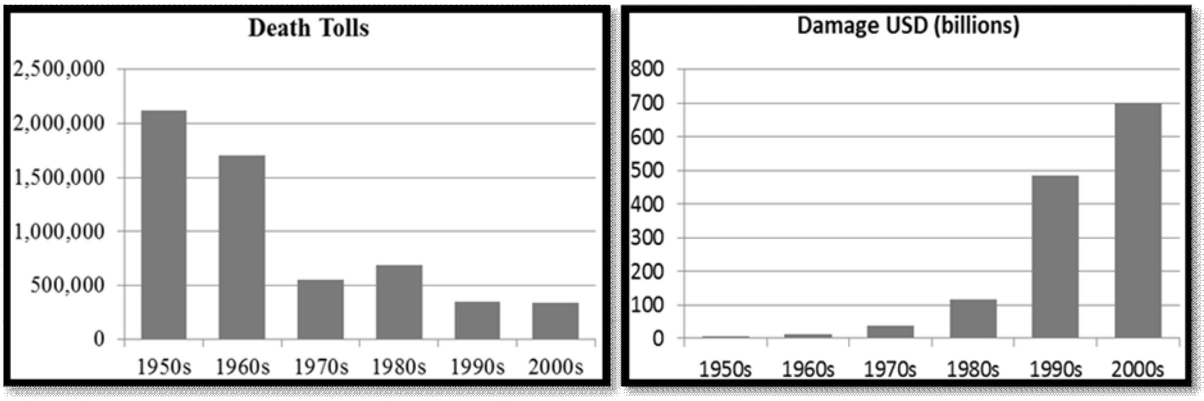

Fig. 1 Trend of reported economic damage and death tolls by Hydro-meteorological hazards, Source: Based on EM-DAT/CRED.

Fig. 2 Countries with reported death tolls in the Indian Ocean Earthquake and Tsunami in 2004

In November 2011, automobile production fell by 84 percent compared with the same month in 2010. Given that Thailand plays a key role in global supply chains in the electronics and automobile industries, Honda factories in Malaysia, North America and Japan had to reduce or halt production. Total loss of operating profit to Toyota and Honda was estimated at US$1.25 billion and US$1.4 billion, respectively. As in the case of the Japan earthquake, a significant proportion of these losses were because of one affected supplier that produced critical electronic components (Haraguchi and Lall, 2012).

At the time, Thailand also produced 43 percent of the worldôs hard disk drives. During the floods, hard disk drive production fell by 77 percent, causing the price of some hard disk drives to triple between November 2011 and February 2012 (Ye and Abe, 2012).

Global supply chains increasingly supply disaster risks as well as parts and services. For example, a survey of businesses in 62 countries found that 85 percent of organisations had experienced at least one supply chain interruption in 2011. Of these, 51 percent were caused by weather-related hazards and another 20 percent by earthquakes in Japan and New Zealand (GAR 2013 and BCI 2011).

3 TWO MODEL SULUTIONS

Now the question is: How it is possible to avoid such a regional to global spread damages? From the disaster point of view, the basic concept available is only transboundary disaster risk management. There is no royal road but only a step-by-step application of component means in an effective and systematic way. Among them, there are two model sultions to be highlighted here.

3.1 Transboundary Effects of Industrial Accidents Convention

The Convention on the Transboundary Effects of Industrial Accidents is a United Nations Economic Commission for Europe (ECE) convention signed in Helsinki, Finland, on 17 March 1992, that entered into force on 19 April 2000. The Convention is designed to protect people and the environment against industrial accidents. The Convention aims to prevent accidents from occurring, or reducing their frequency and severity and mitigating their effects if required. The Convention promotes active international cooperation between countries, before, during and after an industrial accident.

The Convention helps its Parties, that is States or certain regional organizations that have agreed to be bound by the Convention, to prevent industrial accidents that can have transboundary effects and to prepare for, and respond to, accidents if they occur. The Convention also encourages its Parties to help each other in the event of an accident, to cooperate on research and development, and to share information and technology.

As of August 2013, the Convention has 41 parties, including the European Union, Russia, and most other countries in all parts of Europe, as well as Armenia, Azerbaijan and Kazakhstan. The treaty has been signed but not ratified by Canada and the United States.

At its third meeting, in 2004, the Conference of the Parties adopted an Assistance Programme to support the countries from Eastern Europe, Caucasus and Central Asia and South Eastern Europe in implementing the Convention. The Protocol on Civil Liability for Damage and Compensation for Damage Caused by Transboundary Effects of Industrial Accidents on Transboundary Waters was adopted in Kyiv, Ukraine on 21 May 2003. The Protocol is a joint instrument to the Convention on the Transboundary Effects of Industrial Accidents and to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes. The Protocol was signed by 24 European states but as of 2013, the Protocol has been ratified only by Hungary and is not in force.

3.2 The Water Convention

United Nations Economic Commission for Europe (UNECE) has to tackle a wide range of water quantity and water quality problems: high water stress and overexploitation of water resources, increasing droughts and floods, contaminated water resulting in water-related diseases, etc.

Attempts at solving these complex problems in Europe are further complicated by the essentially transboundary nature of water resources. More than 150 major rivers and 50 large lakes in the UNECE region run along or straddle the border between two or more countries. Twenty European countries depend for more than 10% of their water resources on neighboring countries and five countries draw 75% of their resources from upstream countries.

The UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes is another example of transboundary risk management, which 36 UNECE countries and the European Community have already ratified.

Transboundary flood and drought management has been at the core of the work under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention, done at Helsinki, on 17 March 1992) since its entry into force in 1996. Although the Convention does not address water-related disaster in detail, most of its provisions are fundamental to the management of transboundary floods and drought. Above all, the Convention obliges Parties to prevent, control and reduce transboundary impacts, including those resulting from floods and from unilaterally decided flood protection measures such as dams.

Since the Convention came into force, these core obligations have been elaborated in more detail and expanded in a number of guidelines. Several capacity-building activities have also allowed for strengthening capacity in the region and exchanging knowledge and experience. The Task Force on Flood Prevention and Protection, under the leadership of Germany, has been guiding these efforts. A major achievement was the adoption of the Guidelines on Sustainable flood and drought prevention at the second session of the Meeting of the

Parties to the Convention in 2000. The Guidelines were complemented by the Model Provisions on Transboundary Flood Management, adopted in 2006. It should be noted that work on floods under the Convention has also had an important influence on the work at the level of the European Union (EU): the Guidelines on Sustainable Flood Prevention served as a basis for the EU Best Practice Document on Flood Prevention, Protection and Mitigation, which led to Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks.

In 2003, the Water Convention was amended to allow accession by countries outside the UNECE region, thus inviting the rest of the world to use the Conventionôs legal framework and to benefit from its experience. Once the amendment enters into force, this will be of particular importance for countries that border the UNECE region, such as Afghanistan, China and Iran.

In order to have a better understanding of this convention, the followings are highlighting some articles of the Convention that are important for transboundary disaster risk management:

Article 1: DEFINITIONS

"Transboundary impact" means any significant adverse effect on the environment resulting from a change in the conditions of transboundary waters caused by a human activity, the physical origin of which is situated wholly or in part within an area under the jurisdiction of a Party, within an area under the jurisdiction of another Party. Such effects on the environment include effects on human health and safety, flora, fauna, soil, air, water, climate, landscape and historical monuments or other physical structures or the interaction among these factors; they also include effects on the cultural heritage or socio-economic conditions resulting from alterations to those factors.

Article 2: GENERAL PROVISIONS

The Parties shall take all appropriate measures to prevent, control and reduce any transboundary impact.

Article 3: PREVENTION, CONTROL AND REDUCTION

To prevent, control and reduce transboundary impact, the Parties shall develop, adopt, implement and, as far as possible, render compatible relevant legal, administrative, economic, financial and technical measures.

Article 6: EXCHANGE OF INFORMATION

The Parties shall provide for the widest exchange of information, as early as possible, on issues covered by the provisions of this Convention.

Article 14: WARNING AND ALARM SYSTEMS

The Riparian Parties shall without delay inform each other about any critical situation that may have transboundary impact. The Riparian Parties shall set up, where appropriate, and operate coordinated or joint communication, warning and alarm systems with the aim of obtaining and transmitting information. These systems shall operate on the basis of compatible data transmission and treatment procedures and facilities to be agreed upon by the Riparian Parties. The Riparian Parties shall inform each other about competent authorities or points of contact designated for this purpose.

4 CONCLUSIONS

The top three cases of largest economic losses of natural hazards are GEJET (2011), Hurricane Katrina (2004) and Chao Phraya Flood in Thailand, including the Bangkok area (2011). These three cases revealed well that disaster damage could go beyond the borders.

It is recognized that the components of socio-economic activities are increasingly dependent upon each other and the impact of local disasters may quickly extend to national, regional and global scales through the market network (e.g. supply chains). As societal vulnerability to disasters increases through economic development and globalization, Asia is a ñhot spotò of increasing global disaster risk while local disasters have disrupting consequences anywhere in the world. The assessment methodology on the impacts of extremely high consequent events and cascading events should be more fully focused and developed.

In order to implement this concept of transboundary disaster risk management, a paradigm shift is necessary from focusing on emergency aid and international response operation to risk management before disaster occurs. However, this concept is not easy to implement for transboundary disaster risk management: joint monitoring, forecasting and early warning, coordinated risk assessment and joint planning of measures, and appropriate legal and institutional frameworks are all necessary.

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ESTIMATION OF WATER DISASTER DAMAGES AFTER CLIMATE CHANGE AND AN ADPTATION CONCEPT IN JAPAN

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Abstract: The impact of water disasters, which are flood, slope failure, storm surge and coastal erosion, on climate change were evaluated using numerical models. Each numerical model firstly expresses amounts of physical phenomena such as water depth, and secondly provides the amounts to damage cost multiplying physical amount into unit damage cost for each land use. Then, distribution of the damage cost is shown on the Japanese map. Also each damage map is integrated into one map of damage cost for water disasters after climate change. This map is useful for understanding where high risk areas locate in whole Japan and is helpful for discussion regionally on adaptation for each and all disasters. The damage cost map can support to make a decision of an efficient countermeasure in view of nationwide planning and implementation. However, not only economic aspect but also other factors should be considered for the adaptation under climate change by variety countermeasures with long term view.

Key words : *Flood, Slope failure, Storm surge, Coastal erosion, Compound disasters*

1 INTRODUCTION

Water related impacts are perhaps the most severe outcomes attributed to anthropogenic climate change. The abundance of evidences presented in IPCC AR4 along with many other studies reveals that frequency and intensity of heavy rainfall in high-latitude areas are becoming more intense under enhanced greenhouse conditions. Cocequance includes floods, slope faliures and excessive sediment yields, which leaves immense burden over the worldwide nations to cope with emerging environmental and socio-economical risk of disasters.

Studies in Japan have depicted long-term increases in rainfall intensity (Kajiwara et al., 2003) and frequency (Suzuki, 2004) in the 20th century. Japan, in particular with its mountainous topography and weak geological formations, is especially vulnerable to extreme rainfall driven impacts under changing climate. For example, extreme meteorological events in 2004 caused 326 deaths (3.4 times more than the average for 2000-2003) and resulted in damage cost of an estimated 287.5 billion JPY to agricultural production (2.7 times higher than the average for 2000-2003). The number of annual average sedimentation hazards has doubled to more than 2530 throughout Japan. Not only heavy downpour but also sea level rise makes impacts on coastal zone such as beach erosion and storm surge.

In response to the increasing evidence of impacts, decision makeres are commonlly rely on the adaptations measures such as dams, dikes and headlands. By identifying and mapping the areas prone extreme weather events, the spatial distribution of corresponding hazards can be assessed. Moreover, by linking the probability of extreme events in the past with the output of General Circulation Models (GCM), we can create climate hazard maps for the future. In this report, water related impacts in Japan attributed to future climate change was assessed under three important aspects;

1) the cost of flood damage based on changes in extreme rainfall,
2) extreme rainfall induced slope faliure hazzards and
3) coastal damage cost attributed to sea level rise and extrem weather event,
4) beach erosion impact relied on sea level rise in typical beaches in Japan,

and these reccomendations with adaptation were made for the decision-making process in Japan for hazard mitigation through proper regional planning and implementation.

2 THE COST OF FLOOD DAMAGE UNDER CHANGING CLIMATE

2.1 Methodology

The distribution of extreme 24-hour rainfall was obtained using the Auto Meteorological Data Acquisition System (AMeDAS) data from 1980 to 2000. Relationship between return period data at observing stations and rainfall grid data made by Japan Meteorological Agency (JMA) gives us the interpolation method showing distribution of extreme rainfall in each return period. The inundation model is a two-dimensional non-uniform flow model that uses a Manning roughness coefficient to take into account land use. The roughness values were estimated by calibration with respect to many Japanese basins. The land use data were obtained from the Geographical Survey Institute (GSI) of Japan. Extreme rainfall data from continuous periods of 24 hours were applied spatially to the inundation model as input data. Following data input, the inundation simulation was carried out for one week to determine the maximum water depth and inundation period, which were needed to calculate damage costs.

a) Damage costs for 100-year extreme rainfall

b) Damage costs for 50-year extreme rainfall.

Fig.1 Potential damage costs of flooding in Japan

The procedures for calculating the damage cost for each type of land use were determined based on the ñThe Flood Control Economy Investigation Manual ò published by the MLIT (MLIT, 2005) and land-use grid data (KS-META-L03-09M). The following types of land use were included in the analysis: (1) paddy fields, (2) other agricultural lands, (3) residential areas, (4) golf courses, (5) traffic zones, (6) forests, (7) barren lands, (8) other land, (9) rivers and lakes, (10) beaches, and (11) coastal zone.

2.2 Results

We applied the inundation simulation to a scenario in which Japan implements no flood control measures and is subjected to extreme rainfall. We selected 5, 10, 30, 50, and 100 years as the return periods and estimated potential damage costs for the flooding. Figure 1 shows the distribution of damage costs in Japan for extreme rainfall with 50- and 100-year return periods. The cost of damage in the different areas is very similar because Japan is primarily mountainous and only has small plain areas. Therefore, inundation areas do not expand to wider regions, even though the floodwater depth increases. This means that damage costs in the same areas increase as rainfall intensity increases. Large and highly populated cities have large damage costs due to the concentration of assets. These cities include Tokyo, Nagoya, and Osaka, which are located in lowlands.

To prepare cost-benefit analysis in the future, we evaluate the benefit of flood protection. Table 1 shows the damage cost for each return period. In the same approximation of flood defense completion for 50-years flooding, the benefit to protect 100-years flooding is the difference in damage costs between a return period of 50 years and of 100 years, which equals about 210 billion USD. The increase of potential damage cost is same as the benefit to protect 100-years flooding. The extreme rainfall shifting from 50- to 100-year return periods results in damages of approximately 10 billion USD damage per year, which is equal to the benefit of implementing infrastructure construction for flood protection. The annual expenditure for flood control in the MLIT regular budget is nearly 10 billion USD, which is similar to the expected damage costs. An analysis of cost-benefit ratios is necessary in order to estimate construction costs, which will make up a lower percentage of the MLIT budget.

Table 1 Annual expected damage cost and return periods. Interval average damage is estimated from damage costs associated two return periods. For example, interval average damage, interval probability and average annual expected damage cost of the 30-year return period are, respectively, (550-380)/2.0, 0.100-0.033, and 660 X 0.067. (Unit: Billion USD)

Return period	Annual extreme probability	Damage cost	Interval average damage	Interval probabilit y	Average annual expected damage cost
5	0.200	380			
10	0.100	550	470	0.1	47
30	0.033	770	660	0.067	44
50	0.020	910	840	0.013	11
100	0.010	1,120	1,020	0.010	10

3 EXTREME RAINFALL INDUCED LANDSLIDE HAZZARDS

3.1 Methodology

A probabilistic analysis approach is implemented in order to

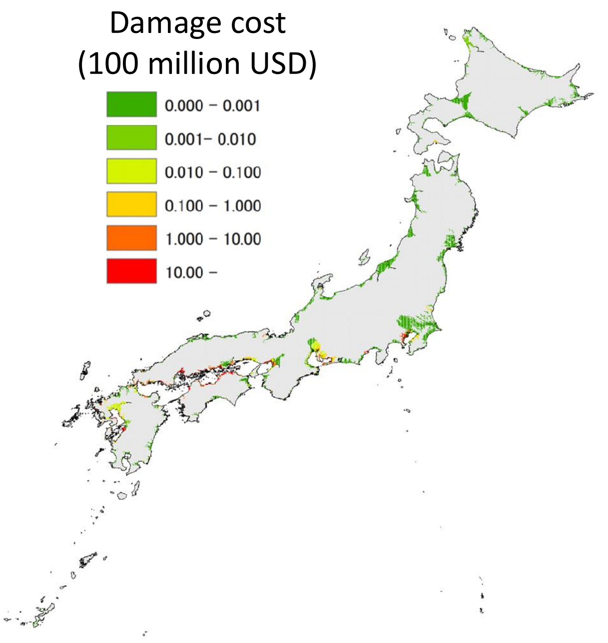

Fig.4 Distribution of damage cost by storm surge in around 2050 with RCP2.6

evaluate the landslide vulnerability over Japan, with consideration of the influences of extreme rainfall. Extreme precipitation of several return periods (5 years, 30 years and 100 years) are estimated by analyzing recorded maximum 24 h precipitation data for 20 years (1980ï 2000), obtained from 1024 AMeDAS (Automated Meteorological Data Acquisition System) meteorological observation stations. For the frequency analysis of the return period of extreme precipitations, GEV (Generalized Extreme Value) ï distribution function is used as probability distribution, and PWM (Probability Weight Moment) method is used for universal prediction method. To evaluate the spatial distribution of maximum precipitation in each return period, a linear regression analysis is used to develop the relationship between the extreme precipitation data and annual mean precipitation data. Annual mean precipitation data are obtained from the precipitation data base of Meteorological department of Japan, which is called ñMesh Climate Value 2000ò (Japanese Meteorological Business Support Center, 2002). To apply the linear regression analysis the inverse distance weighted method and the Tissen method are used to interpolate precipitation values. Figure 2 shows the distribution of the extreme precipitation over Japan in 5 years, 30 years and 100 years return periods. This map illustrates that maximum precipitation is lower in Japan Sea side as winter snowfalls are removed from the database. Pacific Ocean side of the Japan receives the highest extreme precipitations. The estimated maximum precipitations are used as the main hydraulic input for the infiltration analysis.

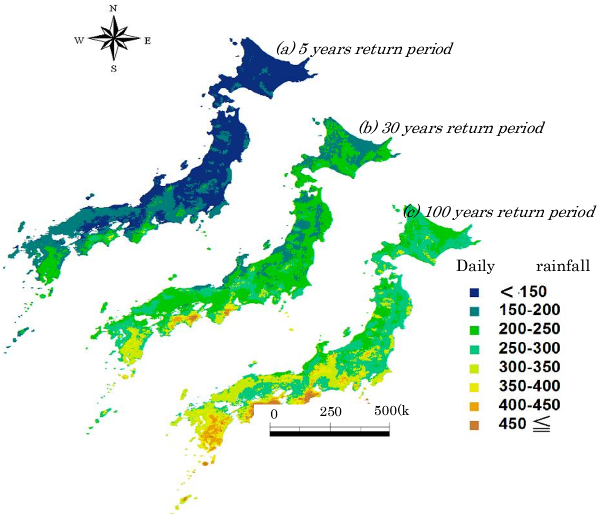

Fig. 2 Distribution of the extreme precipitation (Source: Kawagoe et al., 2010)

Several triggering factors are categorized into groups as hydraulic factors, geological factors and geographical factors. Change in hydraulic gradient (rate of change of hydraulic head per unit distance in a particular direction) due to rainfall is considered as hydraulic factor. The hydraulic gradient is derived from the phreatic line obtained by unsaturated infiltration analysis based on Richardsôs equation using soil data, slope angle and rainfall as the main input. The relief energy (elevation difference between highest and lowest locations), slope gradient and topography are considered as the geographical factors. Four commonly available geological formations in Japan colluvium, Paleogene sedimentary rocks, Neogene sedimentary rocks, and granites represent the geological factors. All interested data are obtained in digital format with 1 km×1 km spatial resolution and are applied to a probabilistic model based on multiple logistic regression method, to evaluate the landslide hazard probability. Finally the results of landslide hazard probability are portrayed in a 1 km×1 km resolution map showing the landslide hazard.

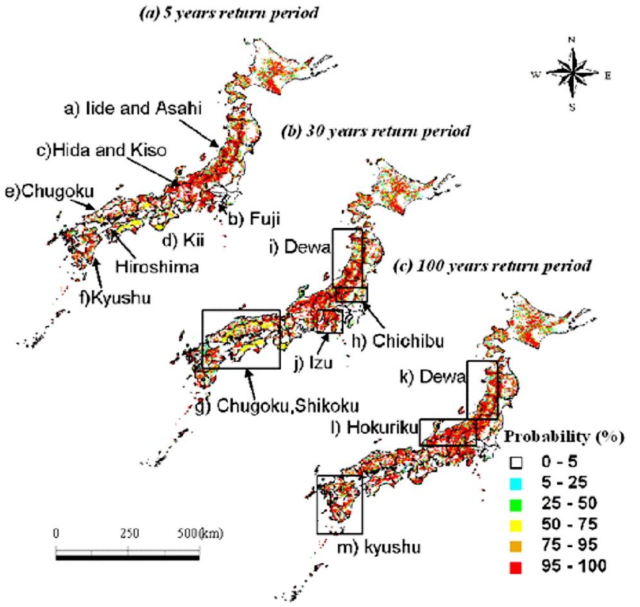

Fig.3 Developed landslide hazard Susceptibility map

3.2 Results

The results of the probability model are portrayed on landslide hazard probability maps using Geographic Information System (ARC/INFO-GIS). In order to evaluate the temporal changes, the probability is estimated for changing hydraulic factors using three different return periods of extreme precipitation; 5 years, 30 years, 100 years (Figure 3). They clearly separate the high risk and low risk areas. The regions where the landslide hazard probability is greater than 95% are marked as high risk areas. Overall, the mountain range on the Japan Sea side shows the highest landslide hazard probability. Especially steep mountain regions spread in these areas.

4 STORM SURGE

4.1 Methodology

To calculate damage cost by storm surge, elevation data is revised depending on structures of coastal dikes and other protections. Then, surge discharge is estimated by the excess water level by storm surge considering tidal variation. The surge discharge into an inland zone makes flat water level on each grid cell on calculation. Here we obtain inundation area, affected people, and damage cost. The affected people is counted with population on the inundated cells. Also potential damage is considered at all areas under the maximum water level including storm surge and tidal variation. After the calculation, the same method to flood damage calculation is carried out depending on land use data. MIROC5, one of GCMs, provides sea level variation in the future in terms of sea level rise. This data is used for future projection of damage cost by storm surge. Finally this calculation is applied to whole Japan to evaluate damage cost by storm surge considering sea level rise.

4.2 Results

In the case of RCP scenario2.6, the simulation was carried out and showed the distribution of damage costs (Fig.4). The coastal zones of Tokyo, Osaka, Ise bays, Setouchi and Ariake have high risk of the damage cost by storm surge. Other areas also have some risks limited. Because high risk zones have a large number of industrial and commercial assets, the potential damage cost relatively become larger similar to flood damages. Once the storm surge runs over the protection structures and expands to wide areas in urban areas locating in lowland along coastal zone. To protect the future storm surge, we must maintain those countermeasure structures as working as expected. Additionally the high risk zones should have more countermeasures for sea level rise by global warming. Especially, GCMs project more typhoons with stronger magnitude in southern regions. It will be necessary to plan and to implement the long-term countermeasures.

5 BEACH EROSION

5.1 Methodology

The past century-scale shoreline changes in the cross-shore direction were investigated at Sendai, Niigata, Kashiwazaki, Kochi, and Miyazaki in order to compare with each beach. These beaches have different physical features, such as grain size, beach slope, and wave height. Wave characteristics were obtained by observation data to esimate annual mean and maximum significant wave height from Nationwide Ocean Wave Information Network for Ports and Harbours (NOWPHAS), which observes real time mean and maximum significant wave height and period at the nearest observation points. Grain size was obtained using the relationship between foreshore slope and grain size described by beach erosion board (1961). This relationship indicates that foreshore slope becomes steeper, and grain size tends to be larger. The century-scale shoreline changes in the cross-shore direction were obtained by adding the average backland boundary change to the beach width change. The beach width changes were obtained by dividing beach area by length of the shoreline. The beach areas and the length of the shoreline were extracted from 1/25000 scale old maps in around 1900, 1950, and 1990 (Kishida and Shimizu, 2000). In addition to these data, we extracted beach areas and length of shoreline from recent maps in around2008. The rate of beach area and length of the shoreline was obtained by calculating with ArcGIS. The backland boundary changes in the cross-shore direction were caused by land-use changes between beach and backland due to change of beach to forest or residential area.

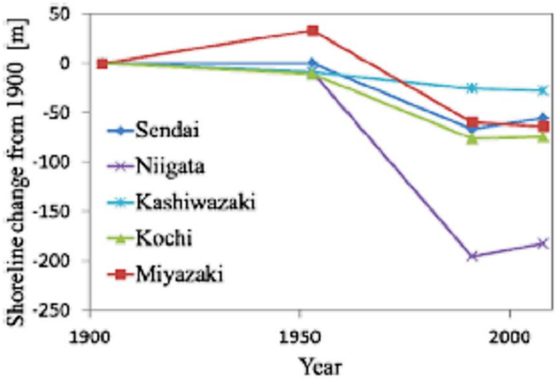

Fig. 5 Past century-scale shoreline changes in the cross-shore direction of five beaches

5.2 Results

Figure 5 shows the past century-scale shoreline changes in the cross-shore direction summarizing five beaches. Shoreline migrated seaward at Miyazaki. Coastal structures, such as seawall, detached breakwaters, and groins, had not been built until Japanese Coast Act was enacted in 1956. Namely, Japan had not installed constructions against natural disasters, only repair work being done on damages caused by natural disasters in coastal zone. Thus, shoreline changes were influenced by natural forces in this period. From 1950 to 1990, shoreline in the cross-shore direction retreated at all study areas, the rate of shoreline retreat was between 20 and 200 m. Notable erosion was caused by the decrease of beach area as a result of the rapid coastal developments since the 1960ôs, the Japanôs high-growth period after World War 2, and by the construction of coastal structures for disaster prevention. Thus, shoreline changes were influenced by human activities in this period. From 1990 to 2008, shoreline in the cross-shore direction changed within 10 m at all study areas, and tended to be stable. Disaster prevention structures functioned appropriately against natural disasters. Japanese Coast Act was revised in 1999, and beach environment and utilization of beach by the public were included in the idea of coastal management in addition to disaster prevention. Accordingly, the rate of shoreline changes decreased compared with the rate of shoreline change from 1950 to 1990. These results show that the current shoreline changes tend to be stable and that this trend is expected to continue. Coastal erosion due to climate change will likely become obvious in the future.

6 COMPOUND DAMAGE

Almost discussion on water disasters in the impact on climate change have been made on each phenomenon individually. However, heavier rainfall in a wide area derives not only floods but also slope failures. Especially, a typhoon hit in the Ise Bay typhoon in 1959 made severe damages caused by river flooding and storm surge. Therefore, we should consider compound water disaster for the impact on climate change to discuss future adaptation for water disasters. This report shows the damage distribution of compound water disaster in Japan and discusses the results.

We selected four typical disasters related water, which are flood, slope failure, storm surge and beach erosion. These are the most concernment disaster under climate change in Japan and the damage costs are bigger than other damage by climate change. The damages of flood and storm surge were estimated from numerical simulation of hydraulic model with digital maps as described. The damage of slope failure was evaluated by probabilistic model with frequency analysis of past occurrence data. The beach erosion was calculated by equilibrium function in sea level and sand beach profile. Damage costs of flood, storm surge, and slope failure were transferred from physical damages into damage cost using economic damage cost evaluation manual in Japan depending on land use. For beach erosion, disappearance areas were multiplied into damage cost per unit area, which is estimated by a travel cost method (TCM). Then, all damage cost maps estimated were composited in whole Japan. Some urban areas facing sea have more than 100 million USD extremely. These areas are affected by combination of flood and storm surge. And the second highest damage areas are made by the combination of flood and slope failure and its cost is from 10 million to 100 million USD. (Fig.6)

7 ADAPTATION

Through the comprehensive evaluation of impacts distributed throughout the Japan, these results are expected to guide decision-makers in identifying the areas that are prone to flood, slope faliures, strom surge and coastal erosion under a changing climate in order to prepare and implement appropriate mitigation measures to cope with the impacts.

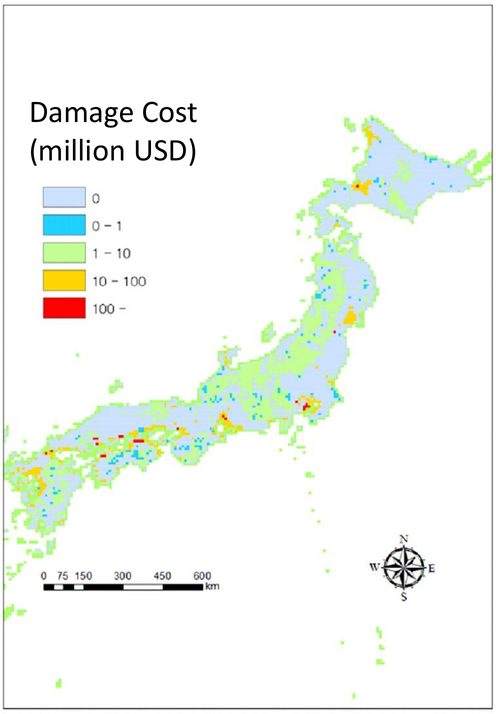

Fig. 6 Integrated damage cost distribution in Japan

Tackling with water disasters under climate change, we do not need special countermeasures and can apply current countermeasure. However, the expenditure of national budget will be larger, and more efficient use should be necessary. This report showed some maps for impact in Japan, which can be used for consideration for effective countermeasures for each region in view of government expenditure. Urban areas have huge expected damage and expect great infrastructures to protect it. On the other hand, rural areas have less damage and select economy measures. This guideline is rational in national-wide view but people in rural areas will not accept it. To reach an agreement for the adaptation, a clear national design is necessary and we spent longer time to implement the design in the future. Therefore, we must consider the speed of climate change and implementation for the adaptation. Spatial and temporal evaluation is needed for the design of adaptation.

Although many researchers have discussed the adaptation for long time, concrete methodology has not been concluded yet. We can collect many options for flood and storm surge. For example, Ministry of Land, Infrastructure, Transportation, and Tourism (MLIT) showed 26 options such as dam, diversion, dredging, insurance and so forth in the report for future flood control. Also MLIT recommended a process to achieve a conclusion of flood control. Any decision for flood control option needs public support because the countermeasure for flood is paid by peopleôs tax. Therefore, economic benefit is more important. Standing on this view, dam construction is more advantage than others in economic aspect in almost cases. On the other hand, environmental impact assessment works well in Japan but does not have any force to eliminate an unsuitable program for environment. These makes more complicated process to obtain consensus of the countermeasure. Although this problem seems to be not for climate change matter but for general policy, climate change makes more confusion and a difficult process for taking consensus and a decision making. Another problem is that it takes a long time to achieve a consensus formation sometimes. Climate change progresses faster than the implementation of countermeasure. Target of protection level will be further and the expenditure will be higher in the future. Theoretically, the earlier implementation is more efficient in economics. However, all structures for flood control are still designed using current climate conditions but consideration of future climate. Then, it seems to me that implementation of adaptation for climate change is unable to be successful. The implementation is initiated by reactive and proactive measures. In adaptation, proactive implementation is preferable but reactive implementation is usually done for disasters. If the protection level changes to higher level, we can consider this is one of the adaptations for future climate as proactive measure.

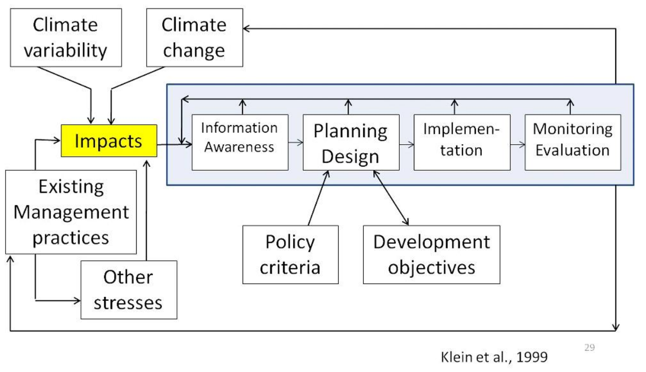

Fig.7 Flow of adaptation

Klein et al.(2009) summarized overall adaptation work as shown in Fig. 7. Although planning and implementation are core of adaptation, monitoring and information awareness are important and more fundamental. Researchers and people in charge of climate change reply on data and indicate the future projection and its problems. However nowadays the number of meteorological and coastal observation stations are decreasing because of a policy of financial retrenchment.

Finally concerns in the future are caused by not only climate change but also other impacts such as land use change and population change. Population growth and urbanization are highly correlated and accelerate potential damage in the future. National design and planning also contribute to reduction of future damage by water disasters. On the other hand, depopulation and abandoned agricultural areas are also severe problems, which are larger cost and poor management. We must consider the adaptation for future water disasters in a comprehensive aspect.

8 CONCLUSIONS

The examples of evaluation of water disasters in the future using GCMs are shown in this report. Flood and storm surge have large potential of the damage cost in the future. If these disasters will occur in the same year, some high economic zones will have the damage more than a few billion USD. We should adapt future change effectively using the damage cost map in view of nationwide discussion. Some national plans for disasters are still going on and the plans chass the climate change. High efficient planning and implementation are expected well than present actions.

(Chapters from 2 to 4 in this paper are almost a direct quote from papers in references.)

ACKNOWLEDGMENT

This research was supported by the Environment Research and Technology Development Fund (S-8) of the Ministry of the Environment, Japan.

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A Proposal to link
Disaster Risk Reduction
to Sustainable Development

DR^{2}AD Model
VERSION 1.0

Disaster Risk Reduction investments Accounts for Development

Japan International Cooperation Agency

1. Background

It has been long said that disasters and development are co-related in a sense that both mortality and economic loss risk are heavily concentrated in developing countries and within these countries disasters disproportionately affect the poor, and that it's impacts have persistent, long-term negative impacts on poverty and human development that undermine the achievement of the Millennium Development Goals (MDGs)[1]. It has also been repeated that once a disaster occurs, the achievements of long-term development efforts may disappear in an instant[2], and that preventive measures against disasters are highly cost efficient[3].

On the other hand, global framework on disasters (Hyogo Framework for Action) and on development (MDGs) both targeted at 2015, are formulated without sufficiently taking into account the co-relation of the two issues. For example, there is not one reference to disasters in the present MDGs framework. JICA considers this gap as one of the bottle necks that prevents integration of disaster risk reduction into all development policy and investments programs. As the global community gear-up consideration of the next generation of the disaster framework (HFA2) and development framework (Post-2015 Development Agenda), a compelling narrative, backed by evidence based research that demonstrates the contribution of DRR investments into sustainable development[4] to bridge this gap is strongly called on.

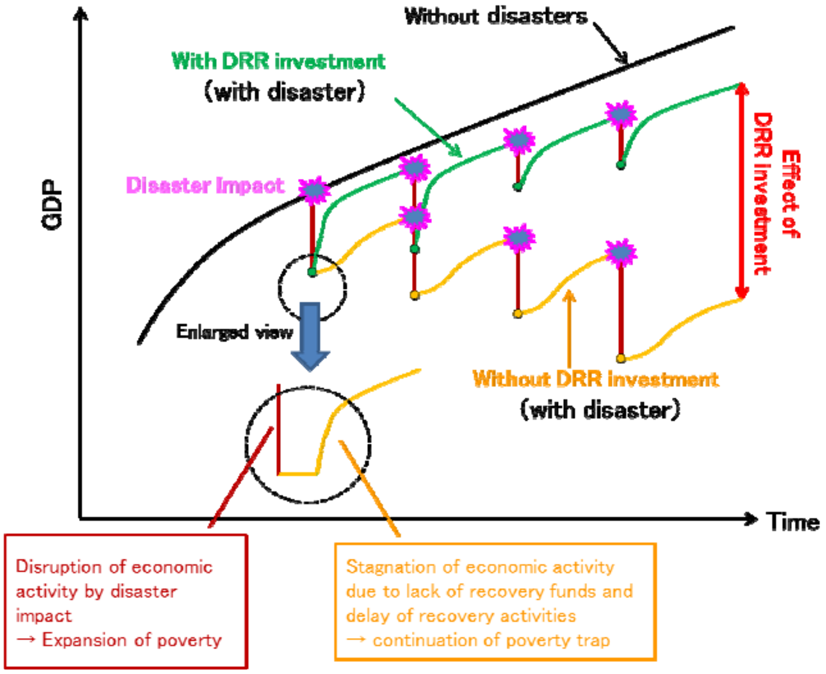

Figure 1.1 Image of verification model of DRR investment effect and its evaluation results (output A)

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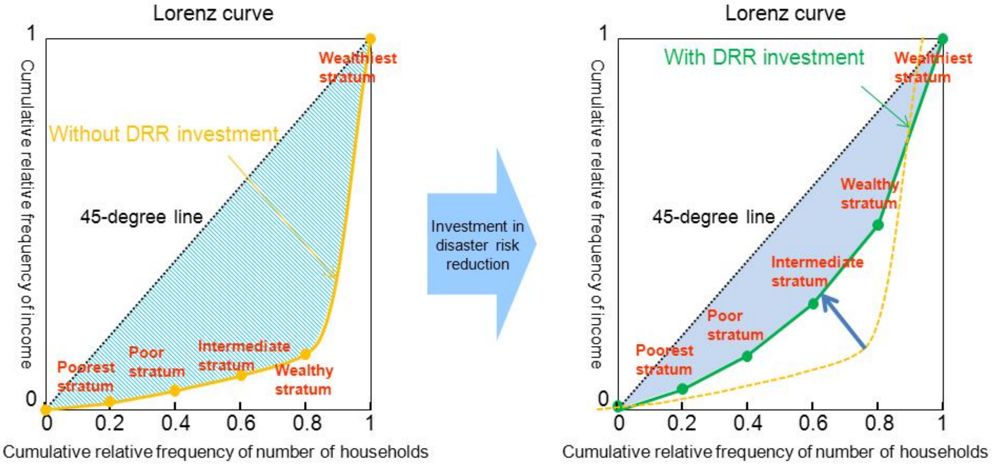
[1] *2009 Global Assessment Report on Disaster Risk Reduction* (GAR2009) (UNISDR, 2009)

[2] *Sendai Statement on Mainstreaming Disaster Risk Management for Sustainable Development* (Joint Statement by the Minister of Finance of Japan, Koriki Jojima and the World Bank President, Dr. Jim Yonog Kim (October 20, 2012, Sendai, Japan))

[3] *Natural Hazards, Unnatural Disasters The Economics of Effective Prevention* (The United Nations and the World Bank, 2009)

[4] *Key Conclusions: Global Thematic Consultation on Disaster Risk Reduction and the Post-2015 Development Agenda* (19-20, February, 2013, Jakarta, Indonesia)

Against this backdrop, together with a team of consultants and academia, JICA has developed a **Dynamic Stochastic General Equilibrium (DSGE) model to simulate impacts on 1) economic growth under long-term disaster risk with or without DRR investment, and on 2) the Gini coefficient in consequence of DRR investment.** The purpose of this model is to quantitatively demonstrate that DRR investment is essential to achieve sustainable development, and to make a compelling explanation that there is definite co-relation between DRR and sustainable development.



Due to the poverty trap, the cumulative relative frequency of income is low and the Gini coefficient high in the poor stratum.
(Note the large area enclosed by the Lorenz curve.)

The Gini coefficient drops as relative income increases in the poor stratum.
(Note the small area enclosed by the Lorenz curve.)

Figure 1.2 Image of verification model of DRR investment effect and its evaluation results (output B)

2. Outline of the Model

The model is named DR^{2}AD Model (hereinafter referred as DR^{2}AD: /diː ræd/), which stands for "Disaster Risk Reduction investment Accounts for Development", with hope that this Model can bridge the aforementioned gap and contribute to the discussions of both the HFA2 and the Post-2015 Development Agenda.

By quantitatively evaluating the processes of economic growth with and without DRR investments, DR^{2}AD enables analysis to identify the best mix of various DRR countermeasures. The analysis will be made by describing differences in the effect of various DRR countermeasures, such as structural measures, non-structural measures, and their combination. For example, damages to properties and human lives are generally mitigated by structural measures, while non-structural measures only counts for mortality and is not to protecting properties, etc. This would enable rational consideration in making decision on DRR investments and the best mix of DRR countermeasures.

Impacts of disaster vary among income classes. DR^{2}AD describes not only the impact on macro-economic growth, but also the impact on various income groups including disaster-triggered poverty trap at household level. If disasters hit low income household and throws them into an economic level of near subsistence constraint, they cannot choose but to decrease time of their children's schooling and have them work for a living, which will result in locking them at low level of human capital and high level of vulnerability. Disaster intrinsically brings more severe damage to lower income people, and therefore, it turns out that DRR investment is more beneficial for the poorer and more vulnerable people.

Followings are some features that outline DR^{2}AD;

2.1 Assumption

People understand disaster risks and make rational decision on savings and human capital formation (education)

Household is divided into five income groups, i.e. wealthiest, wealthy, middle, poor, and poorest.

2.2 Model structure

The following 2 figures show the assumptions of DR^{2}AD on disasters' impact on economic growth.

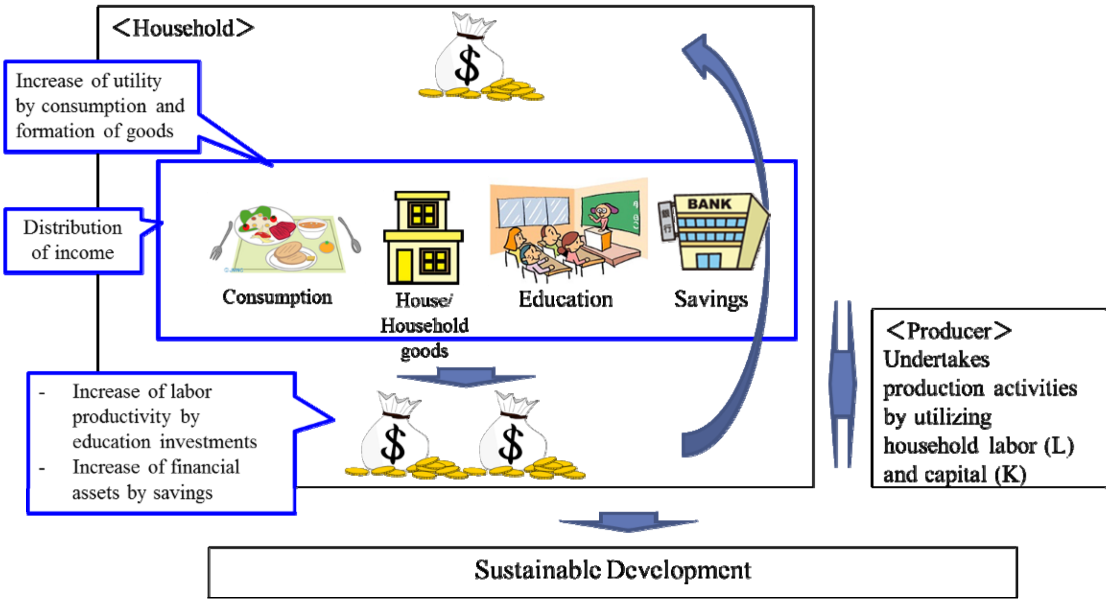


Figure2.1 Structure of DR^{2}AD without disaster (image)

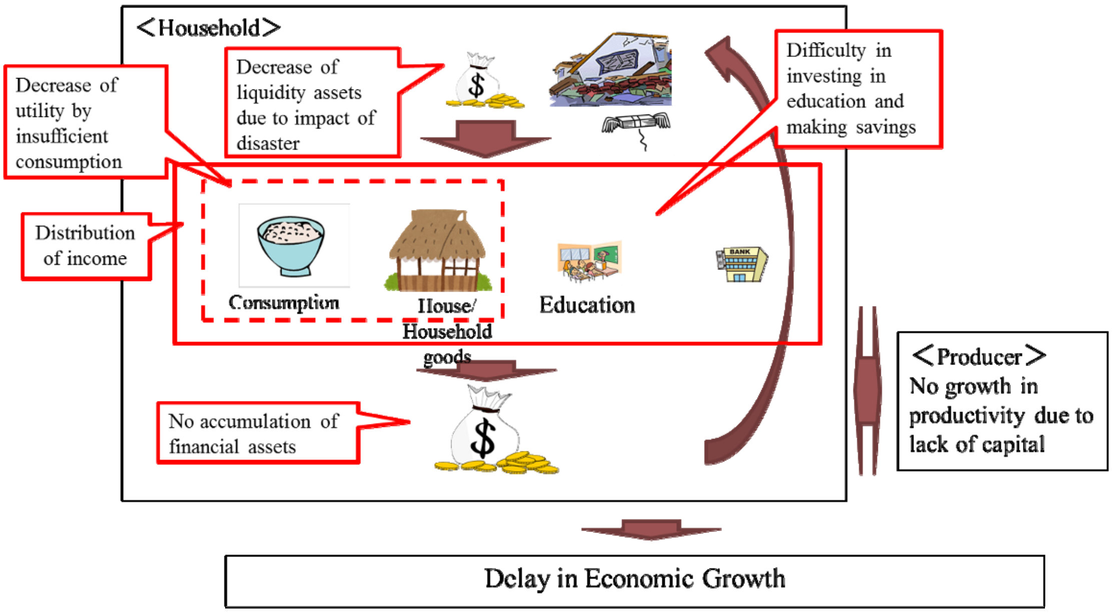


Figure 2.2 Structure of DR^{2}AD with disaster (image)

General structure of DR^{2}AD and relation of elements is summarized as follows. The equilibrium is established between the household activity and enterprise activity, which determines household consumption and investment. Household provides labor and capital to producer's demands.

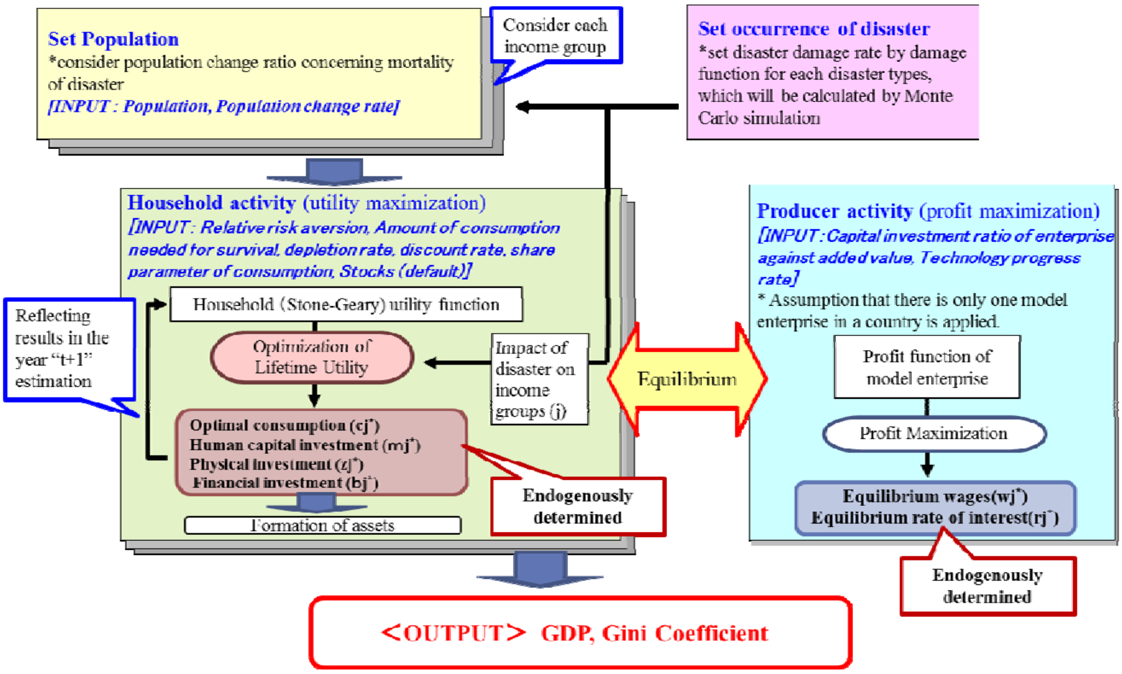
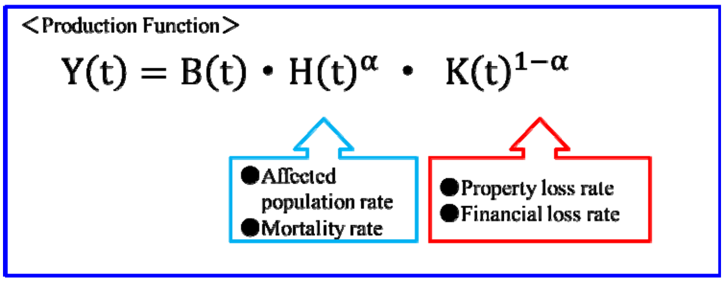


Figure 2.3 Overall DR^{2}AD Structure

2.3 Basic features

Disaster impacts Labor (L) and Capital (K) respectively, thus it is possible to express economic growth incorporating the impact of disasters.



H(t) : Human Capital Stock
K(t) : Financial Capital Stock
B(t) : Exogenous Technology Progress

DR^{2}AD sets utility function for each income class, considering the minimum consumption amount needed for survival. By introducing this Stone-Geary Utility Function into Ramsey Economic Growth Model, demonstrating a way to escape from the so called "poverty trap" is possible.

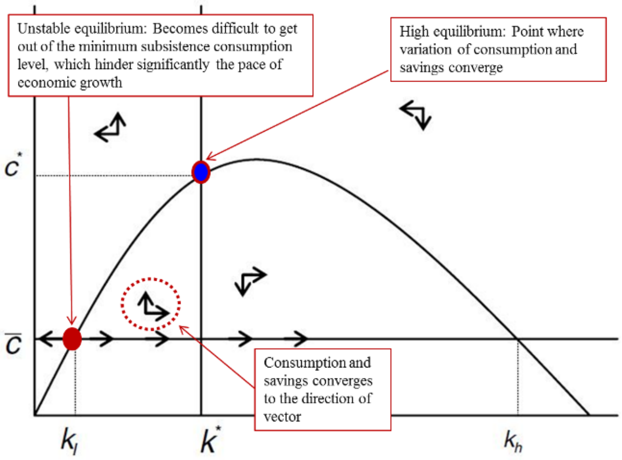
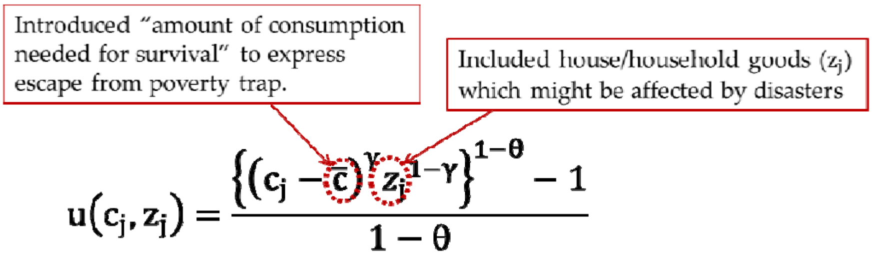


Figure2.4 General conceptual phase diagram expressing the relation between consumption and investment considering the minimum subsistence consumption level $\bar{c}$ [5]



$$u(c_j, z_j) = \frac{\{(c_j - \bar{c})^{\gamma} z_j^{1-\gamma}\}^{1-\theta} - 1}{1-\theta}$$

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[5] Kraay, Aart and Claudio Raddatz (2007) "*Poverty traps, aid, and Growth*" Journal of Development Economics 82 (2), 315-347.

c_j: consumer goods (nondurable)
z_j: house/household goods (physical assets)
: relative risk aversion
$\bar{c}$: minimum subsistence consumption amount (minimum consumption level)
γ : share parameter for consumption

- DR^{2}AD expresses the case that human capital investment negatively affected by disaster, will have long term effect on economic growth and poverty reduction. Human capital formation is assumed as follows:
  a) Investment in education → b) Improved school enrollment rate →
  c) Improved labor productivity → d) Improved income

Education investments promotes accumulation of Human Capital, but as education investment increases investment effect is depleted.

Human Capital is naturally depleted (Knowledge is generally degraded when left un-maintained).

Duration unable to attend schools, due to disaster impact, is set as disaster affect, which is subject to natural depletion.

$$dh_j = \{\eta(m_j) - \delta_h h_j\}dt - \omega h_j dq$$

δ_h : depletion rate (δ: delta), $\eta'(m_j)>0$, $\eta''(m_j)\leq 0$
ω_j : disaster affected population rate
h_j : human capital
m_j : human capital investment (education, etc.)

- DR^{2}AD considers liquidity restriction, which reflects that the poor income group will be restricted access to recovery loan (liquidity) after being impacted by disaster. By considering liquidity restriction, disaster impact will cause reducing or cutting human capital investment. This will push the poor group into a more difficult situation of escaping the poverty trap, forcing them to limit their investment.

$$(0 \leq)\ z_j + c_j + m_j \leq rb_j + wh_j$$

(physical capital investment + consumption + human capital investment) ≦(income of the period)

- In order to incorporate characteristics of disaster and its impact to each income class, human capital, property, and financial damage, and well as death rate by income class can be the input data. DR^{2}AD sets damage function based on the presence/absence of disaster risk reduction measures from the record of disasters by utilizing the international disaster database, EM-DAT of the Centre for Research on the Epidemiology of Disasters (CRED).

Financial loss rate (ψ) = Amount of damage / National savings
*Due to lack of data, Property loss rate (φ) is set as the same ratio as (ψ).
Affected population rate (ω) = Affected population / Total population
Mortality rate (ζ) = Mortality / Total population

2.4 Model Outputs

Macro-economic growth (GDP) with and without DRR investment.

Impact of disasters on various income groups and the shadow effect of DRR investment over income groups (Gini coefficient) at the micro-level.

2.5 Variables (Inputs and Outputs)

Variables		Input Data	Output Data
Household data			
c_i	Consumer goods (nondurable)		○
z_i	House / household goods (physical assets)	○	○
θ	Relative risk aversion	○	
$\bar{c}$	Minimum subsistence consumption amount (minimum consumption level)	○	
b_i	Financial savings (financial investment)	○	○
ξ_i	Investment for house / household goods		○
h_i	Human capital	○	○
m_i	Human capital investment		○
δ_h	Depletion rate of human capital	○	
w	Wage rate (per human capital)		○
η_i	Human capital formation		○
γ	Share parameter of consumption	○	
Disaster data			
q	Total of disaster	○	
ς_i	Mortality rate		○
ω_i	Disaster affected population rate		○
ϕ_i	Property loss rate		○
ψ_i	Financial loss rate		○
Macro-economic data			
n_j	Population (household)	○	○
σ	Population change rate	○	
ρ	Discount rate	○	
δ_k	Depreciation rate of financial capital stock	○	
r	Rental rate		○
B	Growth rate of exogenous technological change	○	
α	Labor relative share	○	
Real GDP			○
Gini Coefficient			○
Benefit			○

3. Verification of the Model

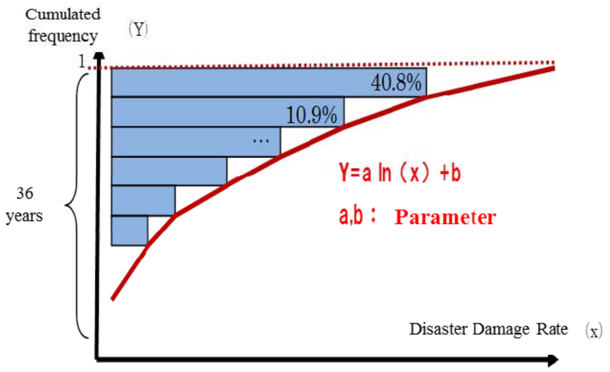
3.1 Pakistan case study

JICA have applied the case of Pakistan to verify DR^{2}AD. The reason that Pakistan case was applied is as follows:

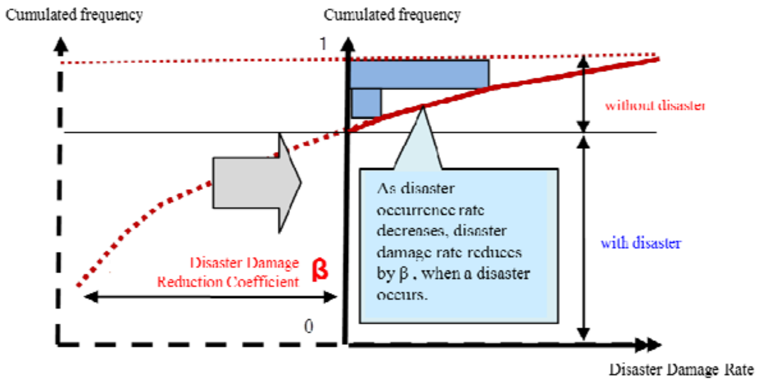
- Pakistan is vulnerable to natural disasters and has experienced major earthquakes and flood impact in the recent years.

- Statistical data, including those according to income class is well existing[6].
- UNISDR and UNESCAP have presented variations of Pakistan's actual observed GDP and projected GDP without disaster for the period 2004-2011[7], thus comparative verification was possible.

Disaster damage rate was set taking the data of 1976-2011 (36 years) from EM-DAT for earthquake, flood, and storm.



Since there was data limitation on the cost-benefits of DRR investments, "disaster damage reduction coefficient ( )" was applied to estimate the benefits of DRR investment reducing by half the largest disaster damage rate in the past 36 years.



As disaster occurrence rate decreases, disaster damage rate reduces by β, when a disaster occurs.

Monte Carlo simulation was used to estimate future disasters and to analyze changes in economic growth (GDP) and social gap (Gini coefficient) with and without DRR investment for the period from 2005 to 2042 (38 years). The outputs are as follows:

---

[6] *World Databank* (World Bank)
Household Integrated Economic Survey (Federal Bureau of Statistics, Government of Pakistan, Islamabad)
Pakistan Economic Survey (Finance Division, Government of Pakistan)
Pakistan Millennium Development Goals Report (Government of Pakistan, 2010)
Poverty Profile Islamic Republic of Pakistan (Japan Bank for International Cooperation, 2007)

[7] *Reducing Vulnerability and Exposure to Disasters* (UNESCAP and UNISDR, 2012)

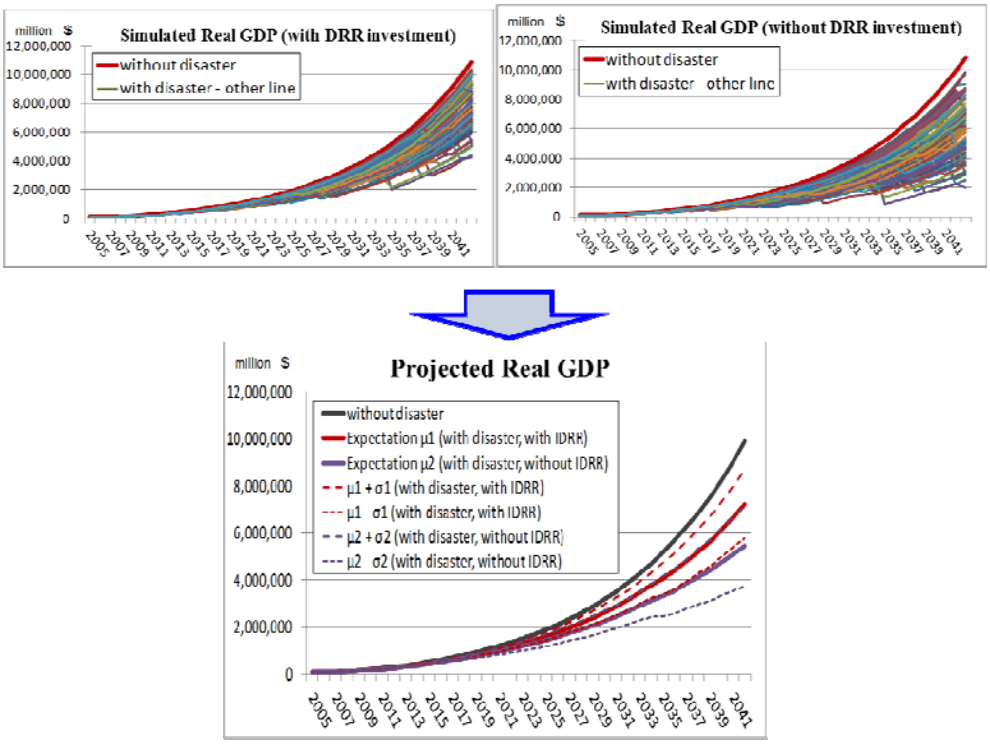


Figure 3.1 [OUTPUT 1] Expected GDP when DRR investment is made is about 25% higher in 2042 than that without investment in disaster risk reduction.

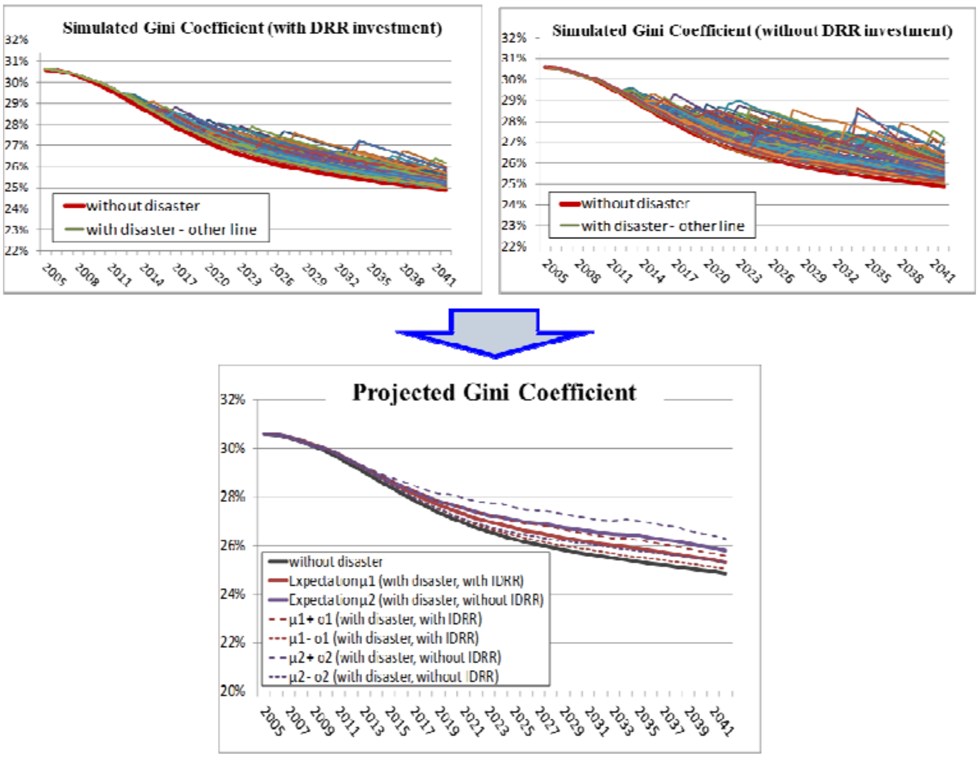


Figure 3.2 [OUTPUT 2] In case DRR investment is made, the Gini coefficient for 30 years starting from 2012 tends to improve relative to cases without DRR investment. Calculation shows about 0.5% improvement in the year 2042, thereby confirming that investment can reduce social disparities and have a positive effect on reducing poverty.

3.2 Conclusion

From these two outputs, it has been confirmed that DR^{2}AD is applicable to the case of Pakistan. Through this exercise, following conclusions have been drawn out:

> **In case DRR investment is ensured, approximately 25% more economic growth (real GDP) is projected at the year 2042 compared to the case without DRR investment.** This result suggests objectively with tangible theoretical backbone that making DRR investments to reduce the impact of disaster definitely contributes and ensures sustainable development. Additionally, it was observed from the result of Monte Carlo simulation, that without DRR investment, variability increased for the future projection of GDP.
>
> **As for the Gini coefficient, a measure of statistical dispersion which measures social inequality, in case DRR investment is ensured, approximately 0.5% lower figure is observed at the year 2042 compared to the case without DRR investment.** It can be said that disaster impact intensifies social disparity; however, with DRR investment before such impact, disaster damage rate can be reduced, and social disparity held down, which leads to social stability. At the micro level, this suggests that DRR investment can contribute to the escape from the "poverty trap". Additionally, it was observed from the result of Monte Carlo simulation, that without DRR investment, variability increased for the future projection of Gini Coefficient.

It has been long said that disasters and development are co-related; however, convincing evidence to support this co-relation has not been offered, which is one of the bottle-necks that prevents integration of DRR consideration into all development policy and investment. Against this situation, **DR^{2}AD is expected to be a solution that provides a compelling narrative and objective evidence that demonstrates the co-relation between disaster and development, more specifically, that DRR investment contributes to sustainable development**.

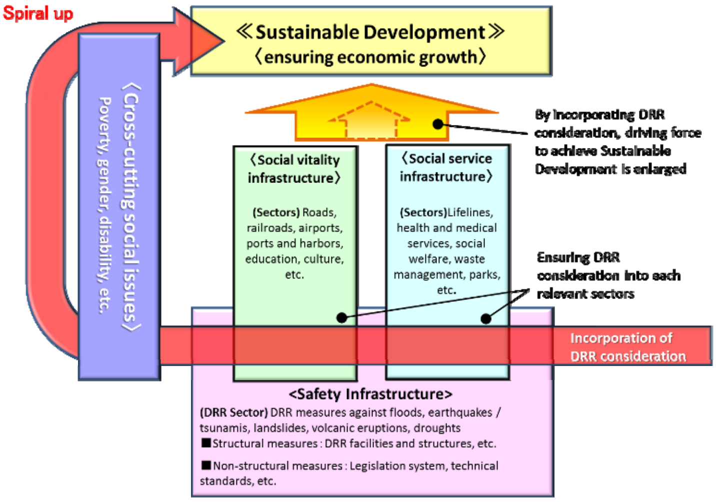


Figure 3.3 Image of co-relation between DRR and sustainable development

4. Limitation and upgrading of the Model VERSION 1.0

DR^{2}AD is an economic model framework that expresses the co-relation between DRR investment and economic growth (sustainable development) not only at the macro-economic level, but also by each income groups and interaction between households and enterprises; however, it should be noted that this framework is developed as VERSION 1.0, and is subjected to improvements and detailed configurations with incorporated expandability of the model. JICA will continue to upgrade the DR^{2}AD VERSION 1.0 to fill-in the limitation that it faces, and at the same time, intends to release and make it an open source, so that everyone who finds this framework useful, can contibute to improving and upgrading the model according to their interests. JICA is preparing to upload DR^{2}AD VERSION 1.0 application to an open website by the end of this year to be utilized by all those interested.

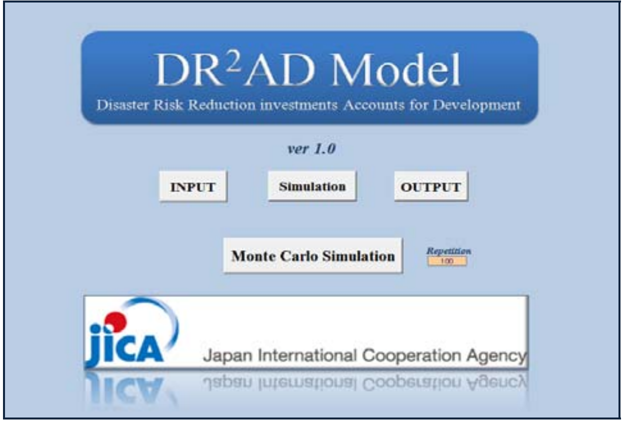


Figure 4.1 Image of DR^{2}AD application to be uploaded in website.

One of the critical limitations that DR^{2}AD VERSION 1.0 inherits is the lack of disaster-related data that exists to fully run the model. Even in the case of Pakistan where statistical data was well in place, there were a number of simplification and presumption made to complete verification. There needs to be further enhancement of data acquisition efforts to track impacts of disasters, especially the data at the micro level.

Another limitation that DR^{2}AD VERSION 1.0 that encounter is the fact that due to time constraints, verification was undertaken using just the case of Pakistan. There needs to be more country cases to be calibrated with this DR^{2}AD VERSION 1.0 to further review its sensitivity as well as to improve and expand applicability.

There are a number of points already listed to be improved from the upgraded version of DR^{2}AD VERSION 1.0.

- Since disaster damage rate impacts the fluctuation of GDP, there needs to be further refinement of the disaster damage rate. A way forward is to set disaster damage rate according to the characteristic and type of disaster. This requires accumulating data on frequency and magnitude of disasters by types, such as damage amount by industrial sectors (primary, secondary, and tertiary) and on household assets.

Difference of recovery period according to types of disasters also needs to be incorporated.

DR^{2}AD VERSION 1.0 does not provide answer to the question on the amount of DRR investment and its co-relation with the extent such investment reduces disaster damage rate. Rather, DR^{2}AD VERSION 1.0 suggests that DRR investment (with the assumption that DRR investment brings in certain reduction on disaster damage rate) does actually contribute to sustainable development. In order for the DR^{2}AD to serve further as convincing and usable tool for policy makers in actually making decision on how much DRR investment to make, there needs to be further refinement of disaster damage rate with DRR investment compared to without DRR investment.

In case of DR^{2}AD VERSION 1.0, data on the disaster damage rate by each income group was not available so it was set as to impact all income groups at the same magnitude. Actual disasters impact more the poorer and vulnerable income groups, thus there needs to be varying disaster damage rate set by each income groups to reflect this reality.

Disaster impact varies not only on income groups within countries, but also between countries and regions according to its characteristics, which is represented by industrial structure of countries and regions, and thus, it is important to reflect the economic activity and the impact of disasters on such activity appropriately. DR^{2}AD VERSION 1.0 featured the household factor to express economic growth, and the enterprise factor was simplified into a one-country-one-enterprise model. Subdividing the industrial sector into primary industry, secondary industry, and tertiary industry to reflect the structural characteristics should be considered in upgrading DR^{2}AD.

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SHIFTING FRAMEWORK FROM DISASTER MANAGEMENT TO DISASTER RISK MANAGEMENT: FEATURES IN THE PHILIPPINE D.R.R.M. ACT OF 2010 AND ITS I.R.R.

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Abstract : This paper mainly refers to Republic Act No. 10121 of the Philippines, enacted by the national government in 2010 replacing a 32-year-old presidential decree, and now known as the Philippine Disaster Risk Reduction and Management Act of 2010. Its set of Implementing Rules and Regulations was adopted later in the same year. Some features of the new Act are highlighted, including: an extended section on definition of terms; the four priority areas associated with four new vice chairpersons of the national council; and the mandate to use as much as 70% of local government funds for disaster risk management in activities before response, relief or recovery, i.e. activities during mitigation, adaptation and preparedness, and 30% as quick response fund. The last part of the paper revisits the terminology in light of international usage, and also to remind that terminology tends to shift together with conceptual framework. Differences in legal, academic and professional-practical usages are cited as examples.

Keywords : Terminology, Legal, Academic, Professional, Practical

1 REPUBLIC ACT NO. 10121

Republic Act No. 10121 of the Philippines (R.A.10121 2010) was enacted by the national government in 2010 replacing a 32-year-old presidential decree (P.D.1566 1978), and is now known as the Philippine Disaster Risk Reduction and Management Act of 2010. Its set of Implementing Rules and Regulations was adopted later in the same year (R.A.10121 IRR 2010). The full titles of the old and new laws are shown in **Fig. 1**.

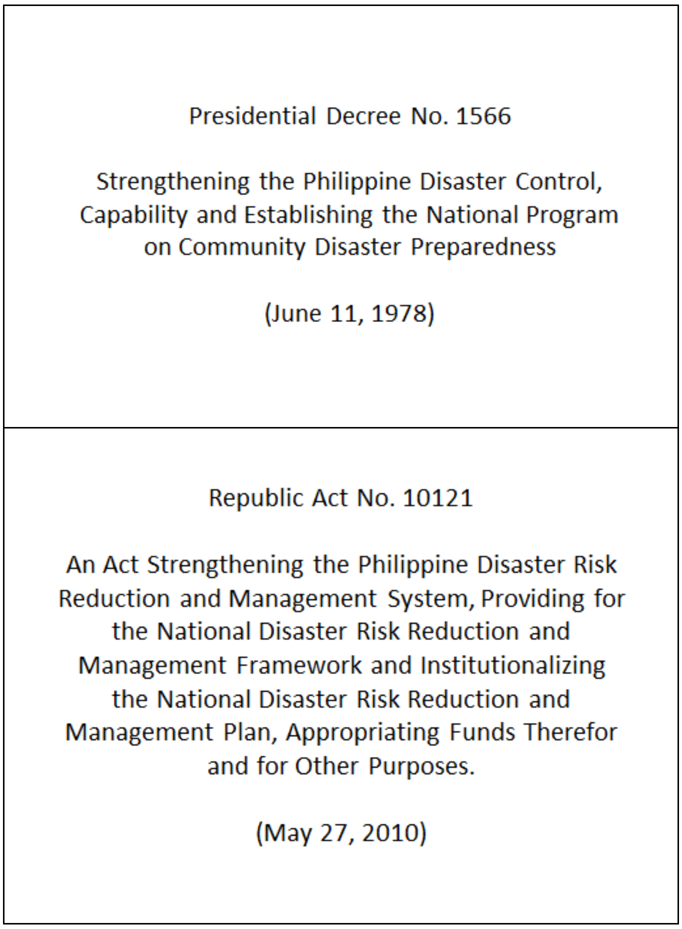
A textual analysis of the new law is summarized in **Table 1**, in terms of sub-sections and lines of text per section. It may be observed that some 25% of all the lines in the text have been devoted to definition of terms, and, in contrast, some 10% to provisions on local disaster risk reduction and management office. Selected salient features of the law are highlighted in this first part of the paper.

For example, the law provides for four new vice chairpersons of the national council, as in **Table 2**. To better understand the intended focus of each vice chairperson, it may be reasonable to go back to the definition of terms (e.g. **Table 3**).

2 TERMINOLOGY AND FRAMEWORK

2.1 Disaster Risk Management

This author believes that it is worth pointing out at the onset that what the Philippine law defines as ñdisaster risk reduction and managementò in its Section 3 (see also **Table 4**) is identical to ñdisaster risk managementò as defined by the UNISDR (2009). Previously, the old presidential decree referred to ñdisaster control.ò



Presidential Decree No. 1566

Strengthening the Philippine Disaster Control, Capability and Establishing the National Program on Community Disaster Preparedness

(June 11, 1978)

Republic Act No. 10121

An Act Strengthening the Philippine Disaster Risk Reduction and Management System, Providing for the National Disaster Risk Reduction and Management Framework and Institutionalizing the National Disaster Risk Reduction and Management Plan, Appropriating Funds Therefor and for Other Purposes.

(May 27, 2010)

Fig. 1 Titles of P.D.1566 and R.A.10121.

Table 1 A Textual Analysis of R.A.10121 in Terms of Sub-Sections and Lines of Text per Section.

Section	*Heading*	*Sub* *	*Lines* **
1	Title		*3*
2	Declaration of Policy	*16*	*82*
3	Definition of Terms	*41*	*291*
4	Scope		*7*
5	National Disaster Risk Reduction and Management Council	*36*	*78*
6	Powers and Functions of the NDRRMC	*17*	*81*
7	Authority of the NDRRMC Chairperson		*10*
8	The Office of Civil Defense		*16*
9	Powers and Functions of the OCD	*18*	*79*
10	Disaster Risk Reduction and Management Organization at the Regional Level		*24*
11	Organization at the Local Government Level	*2*	*48*
12	Local Disaster Risk Reduction and Management Office (LDRRMO)	*4*	*114*
13	Accreditation, Mobilization, and Protection of Disaster Volunteers and National Service Reserve Corps, CSOs and the Private Sector		*23*
14	Integration of Disaster Risk Reduction Education into the School Curricula and Sangguniang Kabataan (SK) Program and Mandatory Training for the Public Sector Employees		*26*
15	Coordination During Emergencies	*5*	*18*
16	Declaration of State of Calamity		*11*
17	Remedial Measures	*4*	*17*
18	Mechanism for International Humanitarian Assistance	*2*	*13*
19	Prohibited Acts	*13*	*53*
20	Penal Clause		*26*
21	Local Disaster Risk Reduction and Management Fund (LDRRMF)		*30*
22	National Disaster Risk Reduction and Management Fund	*5*	*34*
23	Funding of the OCD		*4*
24	Annual Report		*5*
25	Implementing Rules and Regulations		*8*
26	Congressional Oversight Committee		*13*
27	Sunset Review		*9*
28	Repealing Clause		*5*
29	Separability Clause		*4*
30	Effectivity Clause		*4*

** No. of sub-section, e.g. (a)...*

*** Approx. no. of lines in NDRRMC-published copy*

Table 2 Chairperson and Four (4) Vice Chairpersons of National DRRM Council

Secretary of the Department of National Defense (DND) - Chairperson
Secretary of the Department of the Interior and Local Government (DILG) - Vice Chairperson for Disaster Preparedness
Secretary of the Department of Social Welfare and Development (DSWD) - Vice Chairperson for Disaster Response
Secretary of the Department of Science and Technology (DOST) - Vice Chairperson for Disaster Prevention and Mitigation
Director-General of the National Economic and Development Authority (NEDA) - Vice Chairperson for Disaster Rehabilitation and Recovery

Table 3 Selected Definitions from Section 3 of R.A.10121 that May Refer to the ñPriority Areasò of the Four (4) Vice Chairpersons of NDRRMC

(j) "Disaster Preparedness"	the knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions. Preparedness action is carried out within the context of disaster risk reduction and management and aims to build the capacities needed to efficiently manage all types of emergencies and achieve orderly transitions from response to sustained recovery. Preparedness is based on a sound analysis of disaster risk and good linkages with early warning systems, and includes such activities as contingency planning, stockpiling of equipment and supplies, the development of arrangements for coordination, evacuation and public information, and associated training and field exercises. These must be supported by formal institutional, legal and budgetary capacities.
(l) "Disaster	the provision of emergency services

Response"	and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected. Disaster response is predominantly focused on immediate and short-term needs and is sometimes called "disaster relief".
(k) "Disaster Prevention"	the outright avoidance of adverse impacts of hazards and related disasters. It expresses the concept and intention to completely avoid potential adverse impacts through action taken in advance such as construction of dams or embankments that eliminate flood risks, land-use regulations that do not permit any settlement in high-risk zones, and seismic engineering designs that ensure the survival and function of a critical building in any likely earthquake.
(i) "Disaster Mitigation"	the lessening or limitation of the adverse impacts of hazards and related disasters. Mitigation measures encompass engineering techniques and hazard-resistant construction as well as improved environmental policies and public awareness.
(ee) "Rehabilitation"	measures that ensure the ability of affected communities/areas to restore their normal level of functioning by rebuilding livelihood and damaged infrastructures and increasing the communities' organizational capacity.
(aa) "Post-Disaster Recovery"	the restoration and improvement where appropriate, of facilities, livelihood and living conditions. of disaster-affected communities, including efforts to reduce disaster risk factors*, in accordance with the principles of "build back better".
** Identical with “Recovery” definition by UNISDR (2009)*	

Table 4 Selected Definitions from Section 3 of R.A.10121 that May Refer to Risk and Management

(hh) "Risk"	the combination of the probability of an event and its negative consequences.
(jj) "Risk Management"	the systematic approach and practice of managing uncertainty to minimize potential harm and loss. It comprises risk assessment and analysis, and the implementation of strategies and specific actions to control, reduce and transfer risks. It is widely practiced by organizations to minimize risk in investment decisions and to address operational risks such as those of business disruption, production failure, environmental damage, social impacts and damage from fire and natural hazards.
(m) "Disaster Risk"	the potential disaster losses in lives, health status, livelihood, assets and services, which could occur to a particular community or a society over some specified future time period.
(n) "Disaster Risk Reduction"	the concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposures to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.*
(o) "Disaster Risk Reduction and Management"	the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster.** Prospective disaster risk reduction and management refers to risk reduction and management activities that address and seek to avoid the development of new or increased disaster risks***, especially if risk reduction policies are not put in place.
** Identical with terminology and definition by UNISDR (2009)*	
***Identical with “Disaster Risk Management” definition by UNISDR (2009)*	
****Identical with “Prospective DRM” definition by UNISDR (2009)*	

Risk, disaster risk, and disaster risk reduction and management are defined in summary in **Table 4**. In this paper, for the reason stated above, the term DRM is used for convenience.

2.2 Four Priority Areas

The four new vice chairpersons of the national council are assigned to the following ñpriority areas:ò

- Disaster Preparedness
- Disaster Response
- Disaster Prevention and Mitigation
- Disaster Rehabilitation and Recovery.

These four have been variously called ñthematic areas,ò ñstages,ò or ñphases.ò Indeed it is worth pointing out that the language of **Table 2** appears to be a relic of the older framework of ñdisaster management;ò the first two or three ñpriority areasò having counterpart terms also in ñemergency management.ò

The definitions in **Table 3**, particularly for ñdisaster preparednessò and ñpost-disaster recoveryò make an attempt to switch over to the newer framework of ñdisaster riskò management. There is significant confusion remaining, however, why the four priority areas are mainly ñdisaster managementò oriented rather than ñdisaster risk managementò oriented.

2.3 Four Priority Areas of Disaster Risk Management ?

It is worth considering whether or not the terminology as summarized in **Table 5** may be useful to form the following:

- Disaster Risk Mitigation and Adaptation ?
- Disaster Risk Preparedness ?
- Disaster Risk Response ?
- Disaster Risk Recovery and Rehabilitation ?

Firstly, as Twigg (2007) pointed out, while ñmitigation and adaptationò may have been understood very differently in climate change science (where mitigation is usually meant to refer to reduction of GHG in order to ñpreventò climate change itself, while adaptation is usually meant to refer to adjustment by society to climate change ñthat could not be preventedò), in disaster risk management both terms are akin to ñreductionò of disaster risk (see **Table 5**).

Secondly, ñpreparednessò as well as ñmitigation and adaptationò may well be acceptable forms of disaster risk ñreductionò as in **Table 4**.

Still, there is significant conceptual difficulty in associating ñresponseò or ñrecovery and rehabilitationò with ñdisaster riskò (as either term is better associated with ñdisasterò.

Another candidate set of compromise terminology for the so-called four priority areas may be the following:

- Disaster Mitigation and Adaptation
- Disaster Preparedness
- Disaster Response
- Disaster Recovery and Rehabilitation.

On the surface, they still closely resemble the terms of **Table 2** and **Table 3**; however, upon deeper scrutiny they are more closely aligned with the concept of disaster risk. Firstly, the term ñpreventò is no longer associated with disaster risk: disaster risk cannot be prevented, it can only be reduced or otherwise managed. Secondly, putting ñmitigation and adaptationò first and ñrecovery and rehabilitationò last makes a better continuum or cycle of disaster risk management: recovery and rehabilitation must be carried out in such a way as to mitigate and adapt to new risks.

2.4 Management of Risk Factors

Another proposed approach to figuratively divide the work of disaster risk management to a few priority areas or thematic areas, is possibly to view disaster risk in terms of component risk factors, and then to try and manage each risk factor separately. For instance, see **Table 6**.

Table 5 Selected Definitions from Section 3 of R.A.10121 that Refer to Mitigation, Adaptation, Preparedness, Response, Recovery, and Rehabilitation

(x) "Mitigation"	structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation, and technological hazards and to ensure the ability of at-risk communities to address vulnerabilities aimed at minimizing the impact of disasters. Such measures include, but are not limited to, hazard-resistant construction and engineering works, the formulation and implementation of plans, programs, projects and activities, awareness raising, knowledge management, policies on land-use and resource management, as well as the enforcement of comprehensive land-use planning, building and safety standards, and legislation.
(a) "Adaptation"	the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
(bb) "Preparedness"	pre-disaster actions and measures being undertaken within the context of disaster risk reduction and management and are based on sound risk analysis as well as pre-disaster activities to avert or minimize loss of life and property such as, but not limited to, community organizing, training, planning, equipping, stockpiling, hazard mapping, insuring of assets, and public information and education initiatives. This also includes the development/ enhancement of an overall preparedness strategy, policy, institutional structure, warning and forecasting capabilities, and plans that define measures geared to help at-risk communities safeguard their lives and assets by being alert to hazards and taking appropriate action in the face of an imminent threat or an actual disaster.
(gg) "Response"	any concerted effort by two (2) or more agencies, public or private, to provide assistance or intervention during or immediately after a disaster to meet the life preservation and basic subsistence needs of those people affected and in the

	restoration of essential public activities and facilities.
Recovery*	** No separate definition*
(ee) "Rehabilitation"	measures that ensure the ability of affected communities/areas to restore their normal level of functioning by rebuilding livelihood and damaged infrastructures and increasing the communities' organizational capacity.

Table 6 Selected Definitions from Section 3 of R.A.10121 that May Refer to Disaster, Hazard, Exposure, Vulnerability, Capacity, and Resilience

(h) "Disaster"	a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources. Disasters are often described as a result of the combination of: the exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences, Disaster impacts may include loss of life, injury, disease and other negative effects on human, physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation.
(v) "Hazard"	a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihood and services, social and economic disruption, or environmental damage.
(t) "Exposure"	the degree to which the elements at risk are likely to experience hazard events of different magnitudes.
(nn) "Vulnerability"	the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. Vulnerability may arise from various physical, social, economic, and environmental factors such as poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, limited official recognition of risks and preparedness measures, and disregard for wise environmental management.
(b) "Capacity"	a combination of all strengths and resources available within a community, society or organization that can reduce the level of risk, or effects of a disaster. Capacity may include infrastructure and physical means, institutions, societal coping abilities, as well as human knowledge, skills and collective attributes such as social relationships, leadership and management. Capacity may also be described as capability.
(ff) "Resilience"	the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.

It may be said that the disaster risk factors are:

- Hazard
- Exposure
- Vulnerability.

However, just like the way the law has preferred to use the longer term ñdisaster risk reduction and managementò or DRRM instead of DRM, the national DRRM plan prefers to consider that the disaster risk factors are:

- Hazard
- Exposure
- Vulnerability
- Capacity

where ñcapacity,ò it can be argued, is an inverse sub-factor of vulnerability when applied to a community, society or organization. After all, ñvulnerabilityò correctly applies as such when the exposure of interest is indeed a community, society or organization (rather than a property).

This author had argued (e.g. Pacheco 2007) that a good way to shift away from ñdisaster managementò framework is to shift toward a ñrisk factor managementò framework. In a manner of speaking, ñdisaster riskò is more clearly distinguishable from ñdisasterò when the risk factors are focused.

It is worth considering whether or not the terminology as summarized in **Table 6** may be useful to form the following:

- Hazard Management ?
- Exposure Management ?
- Vulnerability and Capacity Management ?

3 FUND

3.1 From Calamity Fund to DRRM Fund

As summarized in **Table 1**, the lawõs Section 21 and Section 22 mandate that the old so-called calamity fund be henceforth regarded as disaster risk reduction and management fund. Not less than five percent (5%) of the estimated revenue from local regular sources shall be set aside as the local DRRM fund.

Said fund is to support ñdisaster risk management activities such as, but not limited to, pre-disaster preparedness programs including training, purchasing life-saving rescue equipment, supplies and medicines, [as well as] for post-disaster activities, and for the payment of premiums on calamity insurance.ò Thirty percent (30%) shall be allocated as Quick Response Fund (QRF) or stand-by fund for relief and recovery programs.

Hence as much as 70% may be used in so-called ñpre-disaster activities.ò It used to be, under the old law, that a declaration of state of calamity would be necessary before any of the calamity fund could be used. Under the new law, proactive disaster risk reduction and management is encouraged and mandated before any actual calamity.

It can be argued that, despite the remaining confusion in the so-called focus areas of DRRM or DRM as discussed above, with the mandated use of funds before any calamity it is clear that the priority is shifting from reactive management of disaster into proactive management of disaster risk.

3.2 Calamity

As summarized in **Table 1**, the lawôs Section 16 and Section 17 provide for the declaration of state of calamity, and the lifting, in order to mobilize the quick response fund, and to set into motion a set of remedial measures.

4 DISASTER PREVENTION AND OTHER TERMS IN INTERNATIONAL USAGE

To quote Twigg (2007), .òôdisaster risk reductionô reflects todayôs holistic thinking and integrated approaches to the disaster problem, but it too will become outdated in time.ò

In this authorôs opinion it might have been unnecessary to have apparently fused ñDRR (disaster risk reduction)ò and ñDM (disaster management)ò into DRRM when a simpler ñDRM (disaster risk management)ò could suffice. Not only a few times have people inquired, what is being managed in ñDRRMò? Is it management of DRR? Is it management of D? Is it management of DR? This author certainly hopes that it is the latter; however, that is not so clear from the legal usage (e.g. Philippine law), nor in academic literature, nor in professional practice.

Terminology and corresponding conceptual framework continue to shift. For as long as the argument is to better manage the risk while it is not yet a disaster, it can be argued that it can suffice to say ñrisk management.ò

Yet the terminology and concept of ñriskò is not so simple, either; hence people, organizations and governments continue to use ñdisasterò depending on their purpose. Some examples are:

- Disaster Prevention (e.g. Tokyo Metropolitan Government 2013, U Han Sein 2013)
- Disaster Mitigation (e.g. Chang 2013, De Castro 2013)
- Disaster Response (e.g. Natale 2013, Chang 2013)
- Disaster Management (e.g. Nakamura 2013, U Han Sein 2013, Gurung 2013)
- Emergency Management (e.g. Natale 2013)
- Emergency Response (e.g. Nakamura 2013, Hartanto and Sudarsono 2013)

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RECENT DEVELOPMENTS OF RUNOFF ANALYSIS AND DISASTER REDUCTION AGAINST GUERRILLA RAINFALL AND LINE SHAPED RAIN BANDS

Tadashi Yamada[1]

[1] **Chuo University, Tokyo** Japan

Flood Disaster caused by Heavy Rain (over total 1,000mm)

Flood and landslide disaster caused by heavy rain (over total 1,000mm) across Japan every year

July, 2006

- Torrential Rain (over total1,200mm)
- 5 dead person, 3,573 flooded houses

	7月豪雨
死者	5名
床上浸水	899棟
床下浸水	2,674棟


Landslide in Kagoshima Pref.


Broken houses by flood in Kagoshima Pref.

July, 2007

- Typhoon no.4 (over total 1,000mm)
- 3 dead person, 1,321 flooded houses

	台風４号
死者	３名
床上浸水	169棟
床下浸水	1,152棟


Flood in Kumamot Pref.


Flood in Kumamot Pref.

July, 2010

- Seasonal Rain (over total 1,200mm)
- 15 dead person, 7,819 flooded houses

	梅雨前線等
死者数	15名
床上浸水	1,806棟
床下浸水	5,813棟


Landslide on pref. road no.74 in Kagoshima Pref.


Landslide under the houses in Kagoshima Pref.

Oct, 2011

- Typhoon no.12 (over total 2,400mm)
- 73 dead person, 27,003 flooded houses

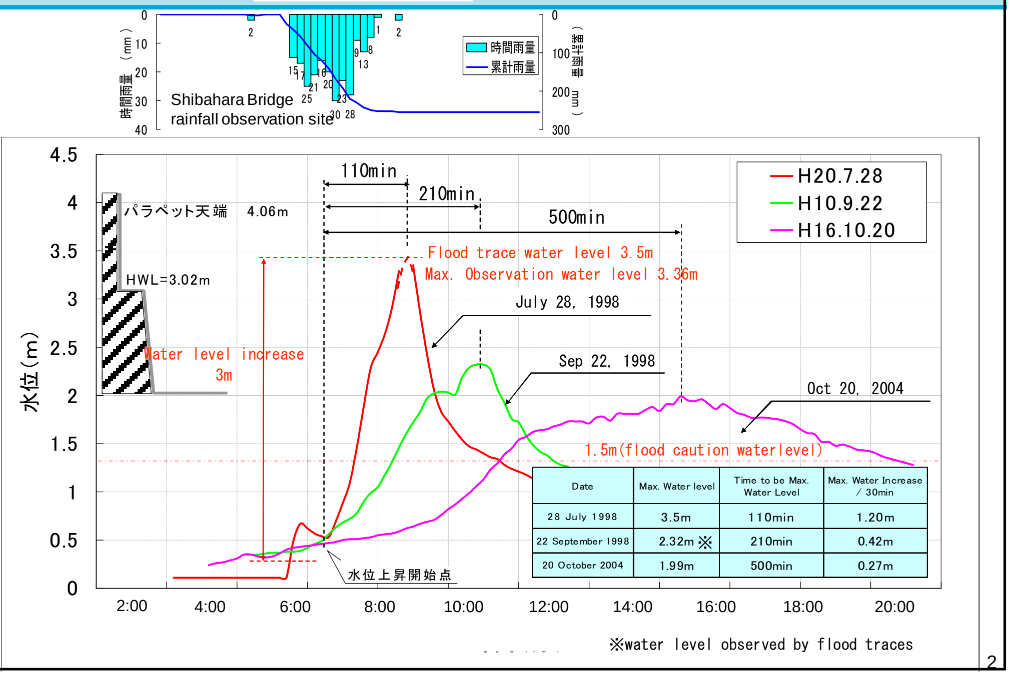
	台風12号
死者	73名
床上浸水	7,836棟
床下浸水	19,167棟

※Oct.19, 2011


Huge damage by flood in Mie Pref.


Huge damage by flood in Wakayama Pref.

July 28, 1998, Rainfall and Water Level at Tenjin Bridge of Asano River

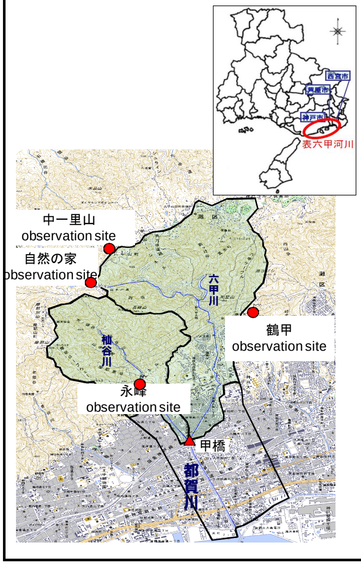


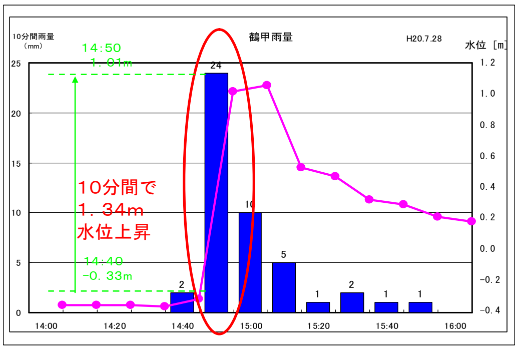
Date	Max. Water level	Time to be Max. Water Level	Max. Water Increase / 30min
28 July 1998	3.5m	110min	1.20m
22 September 1998	2.32m ※	210min	0.42m
20 October 2004	1.99m	500min	0.27m

※water level observed by flood traces

July 28, 1998, Rainfall and Water Level at Kou Bridge of Tsuga River

- Heavy rain around Tsuga river, during 14:30 to 15:00 (specially 14:40 to 14:50)
- During 14:40 to 14:50, water level at Kou bridge observation site increased 1.34m in 10min
- 5 dead person (including children), 11 rescued person and 41 person went to shelter





Water lavel increase at Kou Bridge of Tsuga river（Monitored by Kobe city)

Provided by Kobe pref.

Outline of accident around Tsuga river

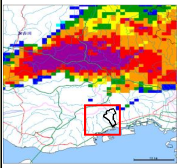
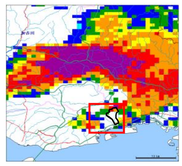
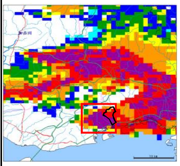
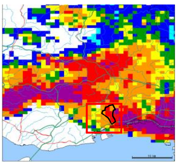
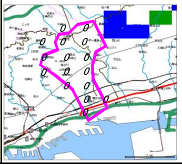
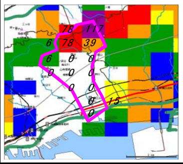
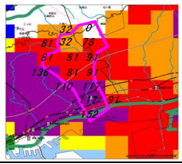
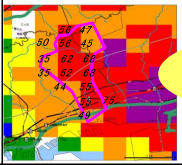
○Weather information on July 28, 1998

∇Kinki area covered with Pacific high pressure in the south sea of Japan. Warm and humid air easily moved into the Pacific high pressure.

∇Extremely unstable air condition caused by the cold in the upper air

∇Heavy rain with thunder in southern Hyogo pref. Rain clouds suddenly expanded around Tsuga river

（provided by:神戸海洋気象台 as of July 30）

	14：20	14：30	14：40	14：50
	No rain around Tsuga river	Rain cloud around river and raining at upper stream area	Heavy rain around all river area	Heavy rain continued
Hyogo south area				
Tsuga river area				

🟪100mm/h～
🟥～100mm/h
🟧～50mm/h
🟨～20mm/h
🟩～10mm/h
🟦～5mm/h
▨～1mm/h
☐0mm/h
■no data

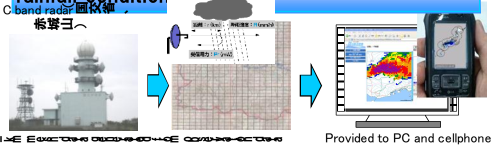
Only 10min for information distribution after observation

Provided by: 国土交通省レーダ雨量観測結果に追

Strengthening local heavy rain observation, prompt distribution

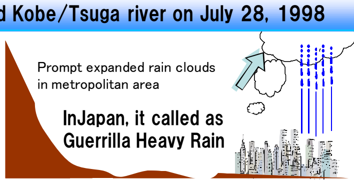
Conventional System

Existing C band radar covering across Japan, Rivers managed by realtime observation of rainfall condition



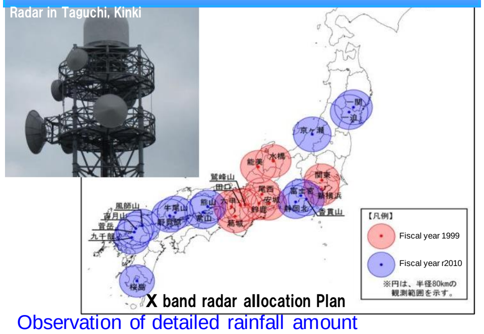
Only 10min to provide the information after observation

The existing radar system was NOT enough to simulate such flood condition as local heavy rain around Kobe/Tsuga river on July 28, 1998



Strengthening the observation System

X band MP radar installed in metropolitan area damaged by local heavy rains many time to strengthen the observation of realtime rainfall condition



Observation of detailed rainfall amount

Accurate and detailed observation of local heavy rainfall condition at a 250m-mesh size 250m

Distribution of realtime rainfall information

Even if suddenly heavy rain generated in 10 to 20min, the information at 1min interval distributed to manage the rivers

※C band radar (wave size 5cm) is effective to observe rainfall in wide area. X band radar (wave size 3cm) is effective to observe realtime and accurate lacal heavy rainfall but observation range is limited.

Advantages of X-band MP radar

1. High resolution: X-band

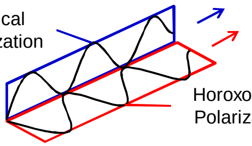
- X-band Radar has shoter wave-length than C-band, and it allows high resolution obasevation.X
（Xバンド：8～12GHz、Cバンド：4～8GHz）

XバンドMPレーダ全景
（NOMIサイト）

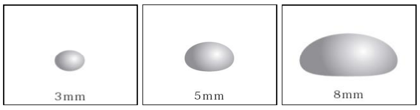
Radar Antenna（Saitama Site）

2. Realtime: MP radar

- Two kinds of polarization (horizonntal and vertical) are emitted to understand the shapes of raindrops, and the flatness of rain drop indicates rain quantity.
- Without ground-truthing with ground-based raingage, precise precipitation observation data can be delivered.



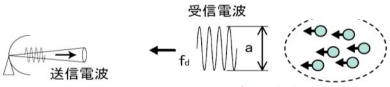
2種類の波を送信



雨粒形状の変化を把握

3. Can observe winds: Doppler Function

- Doppler capability will give the speed of rain drops, leading to wind speed observation

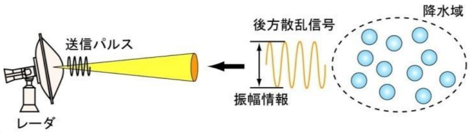


Z_H:反射因子, V_D:ドップラー速度

Conventional Radar and X-band MP Radar

Conventional Radar

Measure strength of precipitation from amplitude of received signal



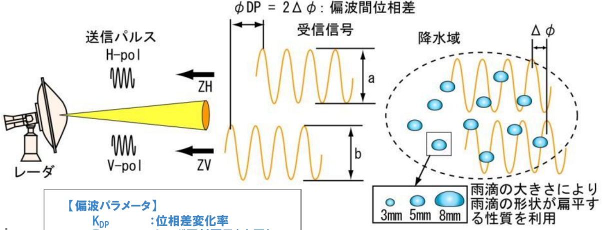
【測定パラメータ】
●反射強度

【観測項目】
●降雨量

Obtainable parameters are different

X-band MP Radar

Various polarization parameters from emitted dual polarization give detailed information on precipitation.2



雨滴の大きさにより雨滴の形状が扁平する性質を利用

【偏波パラメータ】
K_{DP} ：位相差変化率
Z_H ：レーダ反射因子（水平）
Z_V ：レーダ反射因子（垂直）
Z_{DR} ：レーダ反射因子差
ρ_{hv} ：偏波間相関係数
Φ_{DP} ：偏波間位相差

【測定パラメータ】
●反射強度
●ドップラー速度
●スペクトル幅
●反射因子差
●偏波間位相差
●偏波間相関

【観測項目】
●降雨量
●風
●降水粒子のタイプ
●雨滴粒形分布

Conventional Radar and X-band MP Radar

【Comparison】

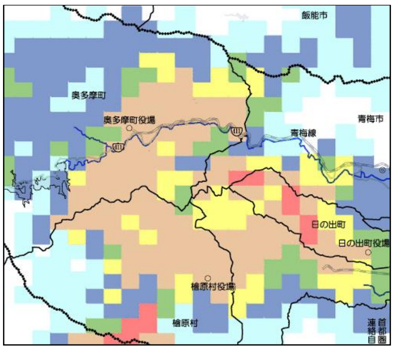
Radar	C-band Radar (Conventional)	X-band MP Radar (New)
Frequency、Wave Length	4～8GHZ、5cm程度	8～12GHZ、3cm程度
Purpose of Observation	Real-time Precip. Obs.(RTPO) Wide Area	・RTPO (Narrow Area/Detail) ・Obs dev. & move. of Rain cells
Observation Interval	5 min.	1 min.
Time to Announcement	5~10 min.	1~2 min.
Resolution	1km	250m
Doppler Observation (Wind Observation)	△(Partially done)	○
Scanning Method	2D scanning	3D scanning (observe developing Rain Drops)
Use of Dual Polarization (Observe shapes of rain drops)	△(partially done)	○

X-band MP Radar

○Introducing high freq. high res. X-band MP Radar to urban areas will improve real-time observations of locally heavy rain (i.e. Guerrilla Rain) to mitigate damages.

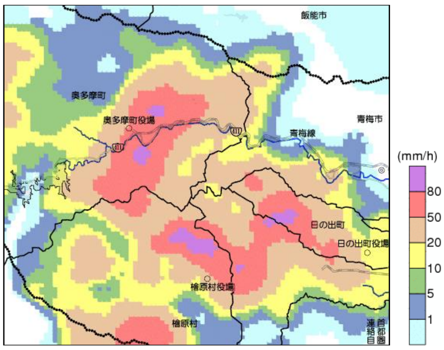
○More frequent(5X)、higher res.(16X) observation than conventional radar. Delivery time of observation data will be shortened from 5~10 min. to 1~2

【Conventional(C-band)】
(Minimum obs. area:1km mesh、Frequency:Every 5 min.
Time from obs. To delivery 5～10min.)



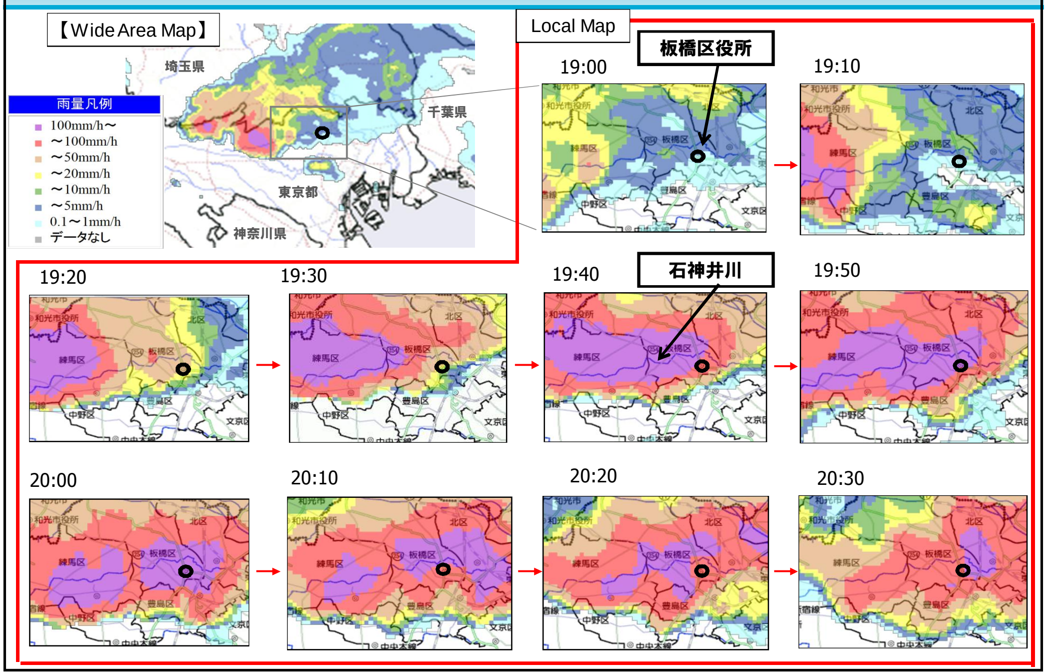
・More freq.(5X)
・High res:(16X)

【X-band MP Radar】
(Minimum :250m mesh、Frequency: every 1 min.
Time from obs. To delivery: 1～2min.)

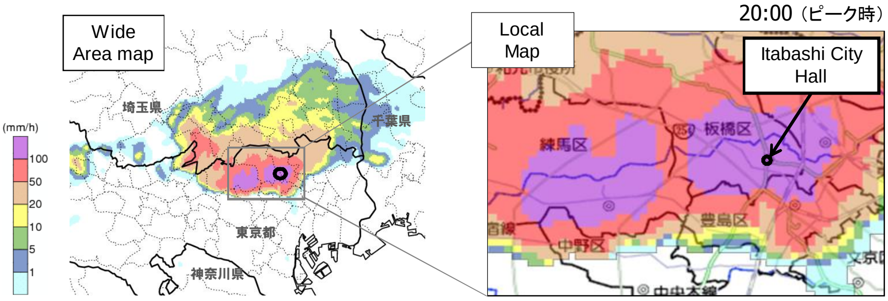


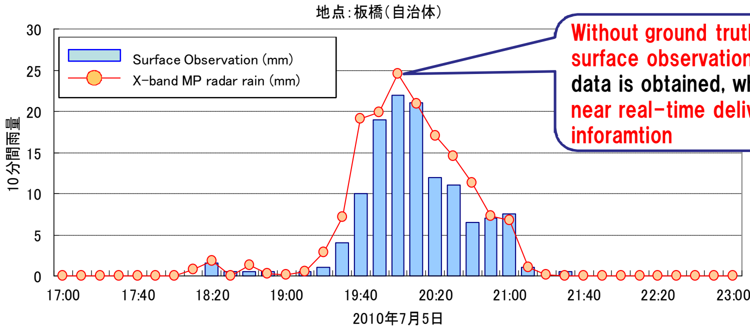
※Cバンドレーダ（定量観測半径120km）は広域的な降雨観測に適するのに対し、XバンドMPレーダ（定量観測半径60km）は 観測可能エリアは小さいものの局地的な大雨についても詳細かつリアルタイムでの観測が可能。

Example of Observation(Kanto Area:2010/7/5 rain)



Example of Observation(kanto Area:2010/7/5 rain)

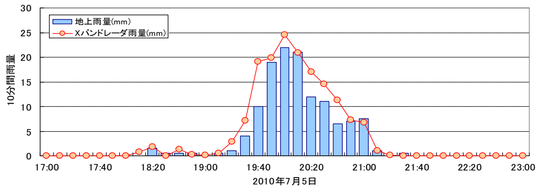




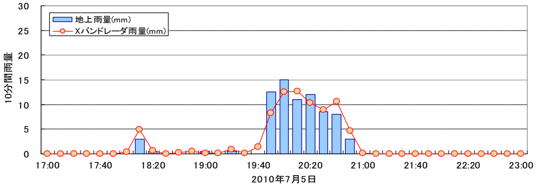
Without ground truthing with surface observation, precise data is obtained, which enables **near real-time delivery of inforamtion**

Example of Observatin(Kanto Area:2010/7/5 rain)

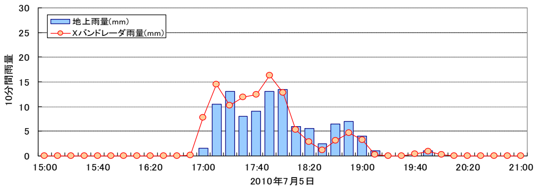
Point Itabashi manual observation



Point Nerima Robotic observation

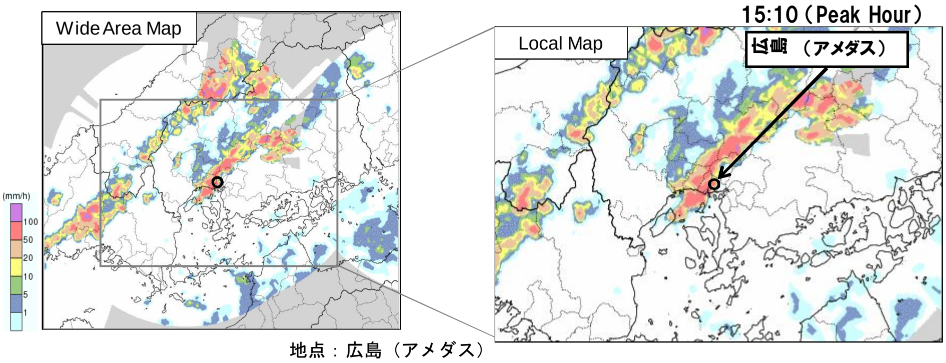


Point Tokorozawa Robotic observation

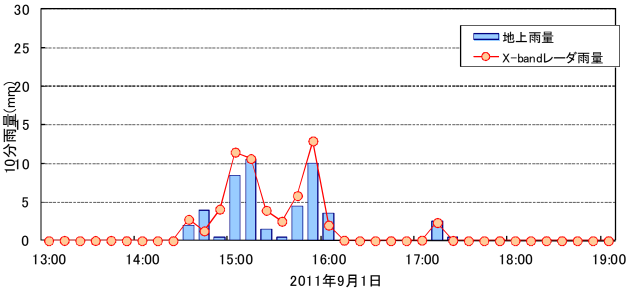


Example of Observation （Hiroshima:2011年/9/1）

15:10（Peak Hour）

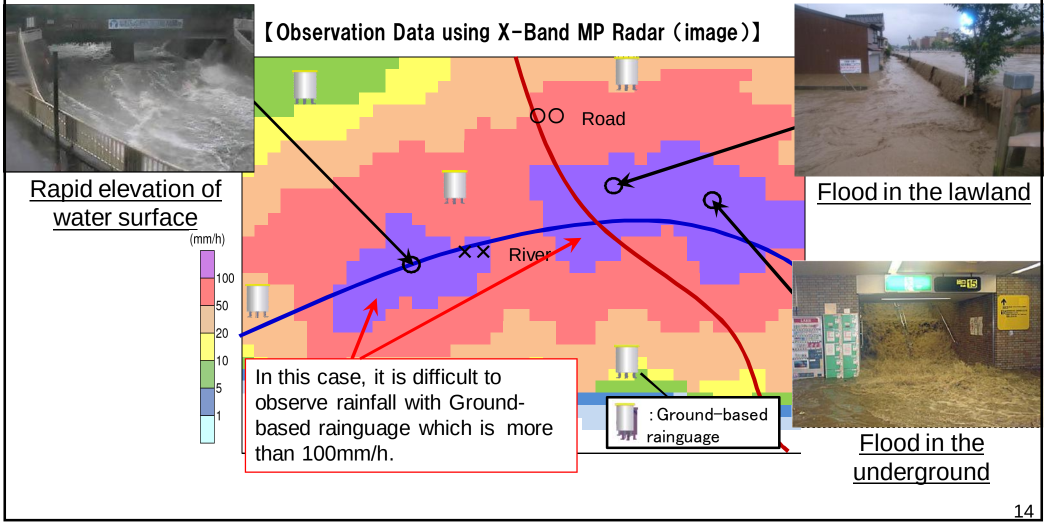


地点：広島（アメダス）



X-Band MP Radar Use

X-Band MP Radar can monitor the high flood risk areas (river, lowland, underground city etc···) on single spot and in real time, which is difficult for Ground-based rainguage to observe.



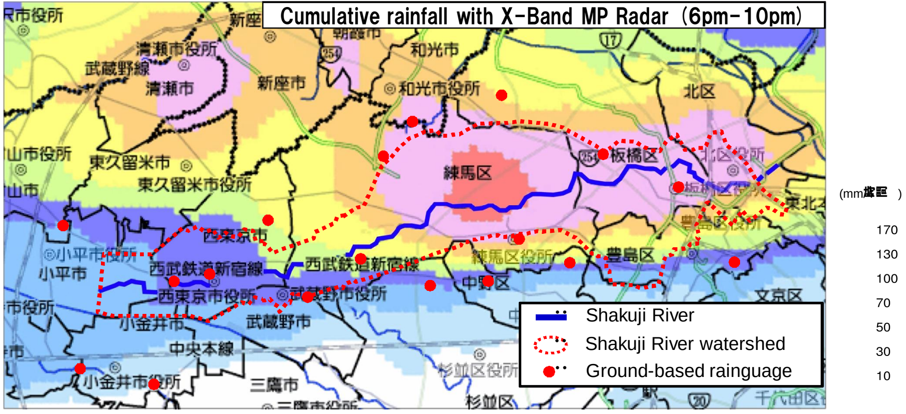
Rapid elevation of water surface

Flood in the lawland

Flood in the underground

In this case, it is difficult to observe rainfall with Ground-based rainguage which is more than 100mm/h.

Areal Monitoring with X-Band MP Radar (Kanto Region:Rainfall in July 5, 2010)



Average rainfall of Shakuji River watershed observed by Ground-based rainguage was 69mm

Average rainfall of Shakuji River watershed observed by X-Band MP Radar was 98mm.

○Average rainfall in Shakuji River watershed observed by X-Band MP Radar was 40% more than the rainfall observed by Ground-based rainguage (7/5/2010).

○X-Band MP Radar can observe areally the local heavy rain with details, which cannot be observed by Ground-based rainguage.

③ The alert mail delivery service using digital data (Handling of natural damming by typhoon 12 that occurred in 2011

○ Alert mails are sent based on precipitation values observed by X-band MP radar over the natural dam and areas which precipitation flow into the dam.

1. System Outline

Alert mail is distributed based on precipitation observed by high resolution radar over natural dams caused by landslides due to Typhonn 12, 2011.

2. Alert Trigger

Two each trigger values are set over the natural dam and areas which precipitation flow into the dam, and when the trigger values are supassed, alert mails are distributed.

	1 hr precip(mm)		Accumulated Precip(mm)	
	Trigger1	Trigger2	Trigger1	Trigger2
①五條市大塔町赤谷	10	—	10	20
②十津川村長殿	10	30	250	350
③十津川村栗平	10	30	550	650
④田辺市熊野	10	—	—	20
⑤野迫川村北股	10	—	20	50

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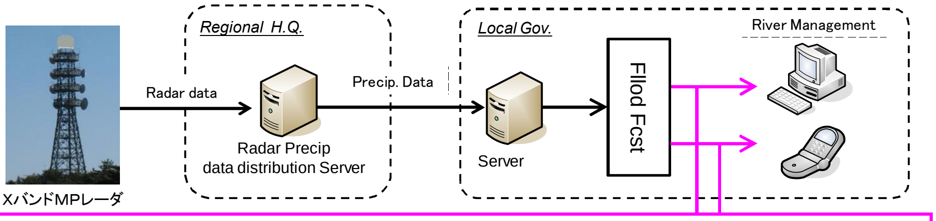
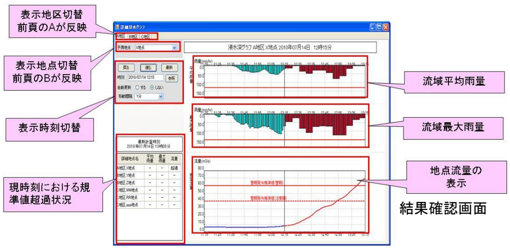
④ Development of Flood and Inundation Monitoring System using X-Band Multi-Parameter Radar

Using X-band MP Radar and distributed flood forecast model, **flow calculation is done for small streams, flood disaster monitoring and prediction system for disaster response is being jointly developed with local governments, and experimental operations are conducted.**

○ Flow of Flood Disaster Monitoring&Prediction



○ 溢水や冠水箇所の流量計算結果、流域の平均雨量や最大雨量設定値をグラフ表示し、設定値を超過時に警報発報



浸水深グラフ A地区 X地点 2010年07月14日 12時15分

時刻 2010/07/14 12:15

最新計算時刻 2010年07月14日 13時05分

詳細地点名	平均雨量	最大雨量	流量
A地区 X地点	–	–	超過
B地区 Y地点	–	–	–
B地区 Z地点	–	–	–
C地区 WW地点	–	–	–
C地区 RR地点	–	–	–
C地区 aaa地点	–	–	–

結果確認画面

○ Example applications below


Hiigh water of main stream floods Branch streams


Collapsed bank floods houses

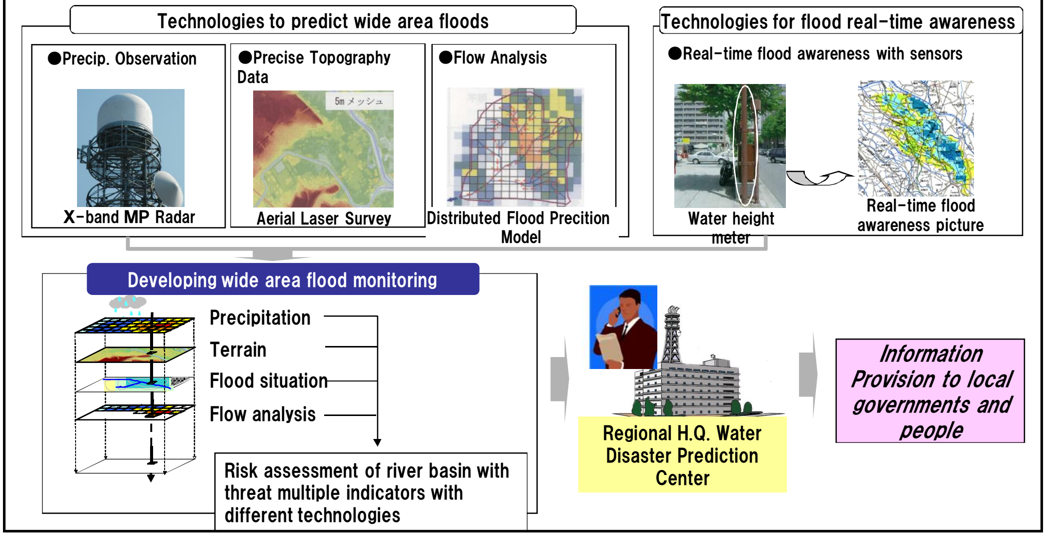

Flooded roads


flooded urban area due to Poor drainage


Flooded rail due to Poor dranage

Development of Flood and Inundation Monitoring System

- In additions to detailed precipitation information with X-band MP Radarm, precise topographic data and flood prediction model, real-time flood monitoring technology contribute to waide areas prediction and monitorting of flood situations.
- Detailed river information to local governments and citizens supports people's proper evacuation.



Technologies to predict wide area floods

- ●Precip. Observation — X-band MP Radar
- ●Precise Topography Data — Aerial Laser Survey
- ●Flow Analysis — Distributed Flood Precition Model

Technologies for flood real-time awareness

- ●Real-time flood awareness with sensors — Water height meter; Real-time flood awareness picture

Developing wide area flood monitoring

- Precipitation
- Terrain
- Flood situation
- Flow analysis

Risk assessment of river basin with threat multiple indicators with different technologies

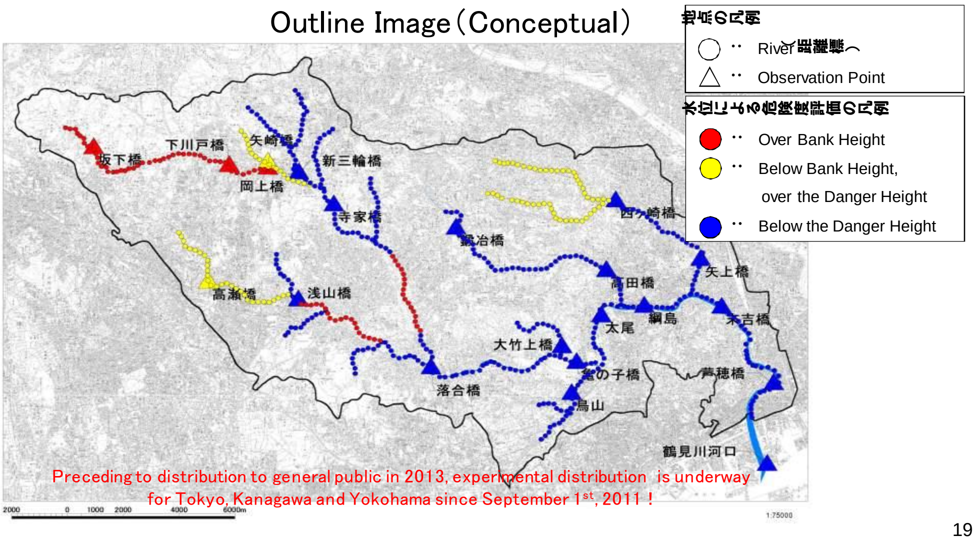
Regional H.Q. Water Disaster Prediction Center

Information Provision to local governments and people

Information providing service of a degree of risk and dangerous level in the Tsurumi River

Calculated data from Distributed Flow Model and predicted flow values are converted into H-Q, and displayed in degrees of flood threat

Outline Image (Conceptual)

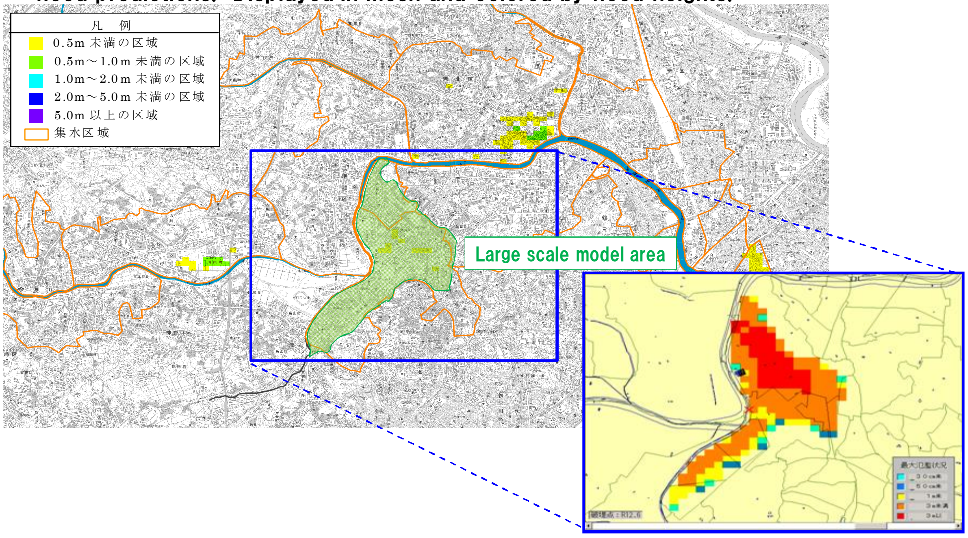


Preceding to distribution to general public in 2013, experimental distribution is underway for Tokyo, Kanagawa and Yokohama since September 1st, 2011 !

Evaluation of the degree of risk of a flood and the inundation(a case of Tsurumi river)

Display of Flooded Areas

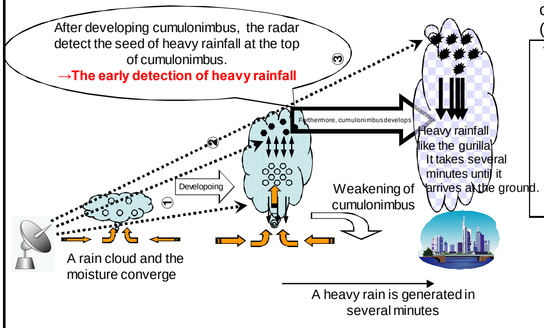
Display of flooded areas, maximum flood height, time-lined flood height based on flood predictions. Displayed in mesh and colored by flood heights.



Advancement of rainfall prediction using X-Band Multi-Prameter Radar

We are expecting that early detection of heavy rainfall, and advancement of the technology of rainfall prediction by wind data.

Image of the early detection of heavy rainfall



Time cycles from generation to development　10 min-20min

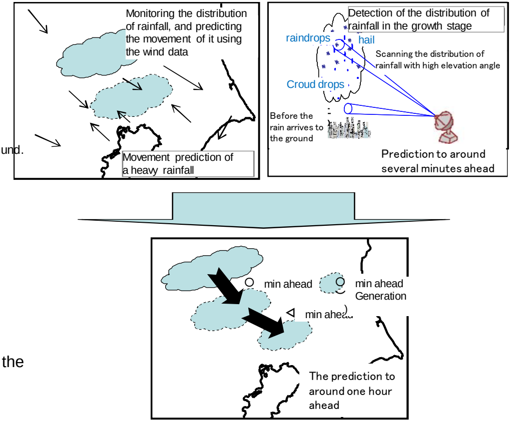
① Monitoring of the distribution of rain cloud, convergence and the emission of the wind in the low altitude area

② Monitoring of the rain cloud after starting growth

③ Detection of the cloud which lead to heavy rainfall like the gurilla

Advancement of the technology of rainfall prediction

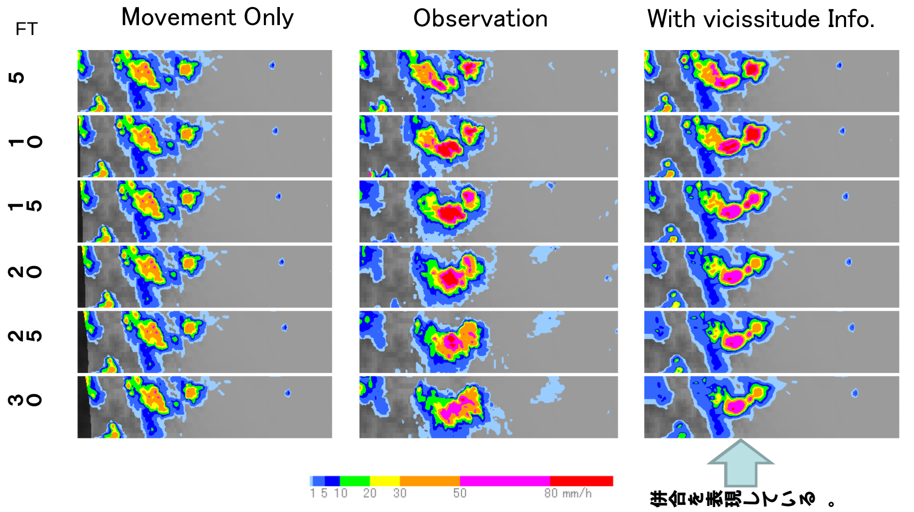
Highly precise rainfa　l prediction by movement history of rain cloud, statement of rain cloud and wind information
(to around 1 hour ahead)



High resolution Nowcast using X-Band MP radar

（Japanese Meteorological Agency）

- ○Flood Nowcast in high resolution（250m mesh and upto 30 minutes every 5 minutes) with **X**-band **MP** Radar will be put into operation in 2013.
- ○Highly frequent and high resolution X-band MP Radar will contribute to better prediction of vicissitude.



併合を表現している 。

THE 7TH WFEO-JFES-AIJ-JSCE JOINT INTERNATIONAL SYMPOSIUM ON DISASTER RISK MANAGEMENT

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