International Program on Resilient Society Development

Under Changing Climate (RSDC)

2112681 Engineering for Water Disaster Mitigation

Kyoto University

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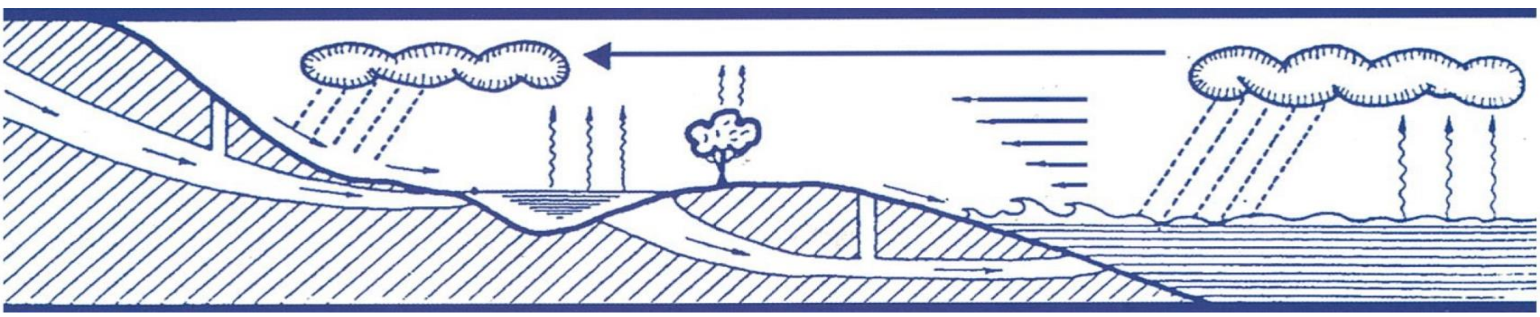

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Chapter 1
Internship (NEWJEC Inc.)

NEWJEC Inc. was established in 1963 as an integrated engineering consultant firm for providing engineering services of survey, planning, designing and construction management for social infrastructure development. NEWJEC Inc. is one of the largest engineering consulting firms in Japan.

1.1 To work as a consulting Engineering

1.1.1 Development Projects – Relevant Parties and Project Cycle

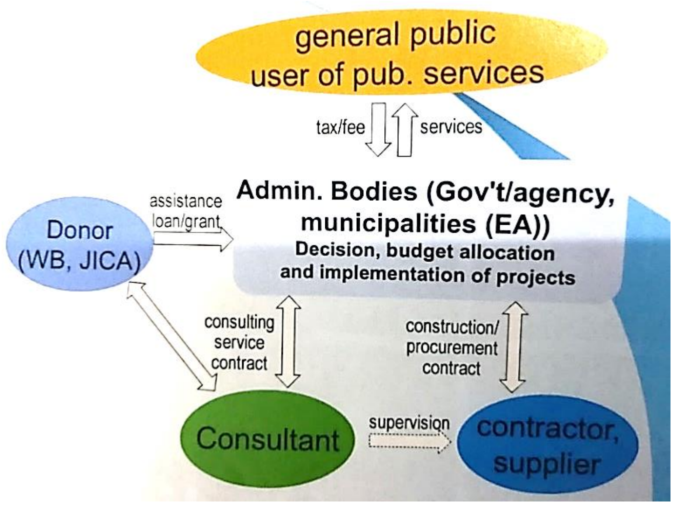

Figure 1-1 Relevant Parties in Infrastructure Development

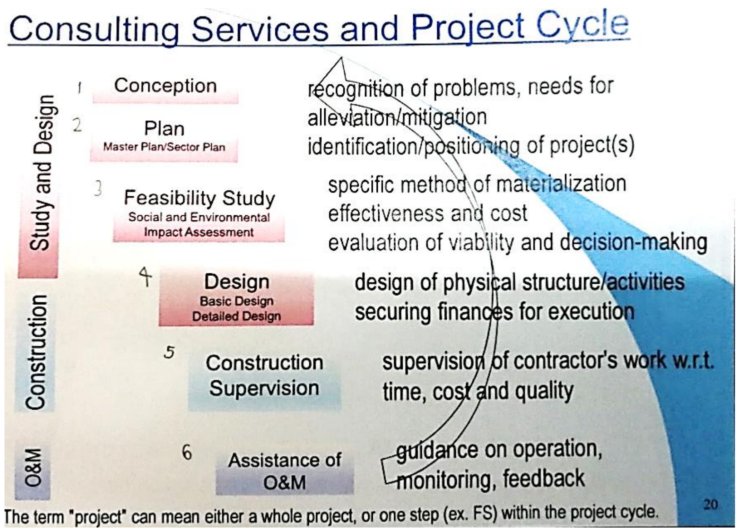

Figure 1-2 Consulting Services and Project Cycle

Project cycle refers to this series of activities. After completion, the project can move on to the next stage (extension, expansion, improvement, rehabilitation, etc.), or can be replicated somewhere else. Therefore, one project does not end when completed. This is another side of “cycle”.

1.1.2 Work of Consulting Engineers

There are several “studies” in a project cycle, pre-feasibility, feasibility, detailed design study, etc. They take more or less a similar process regardless of what the study is about. This section describes about process of feasibility studies (Figure 1.3).

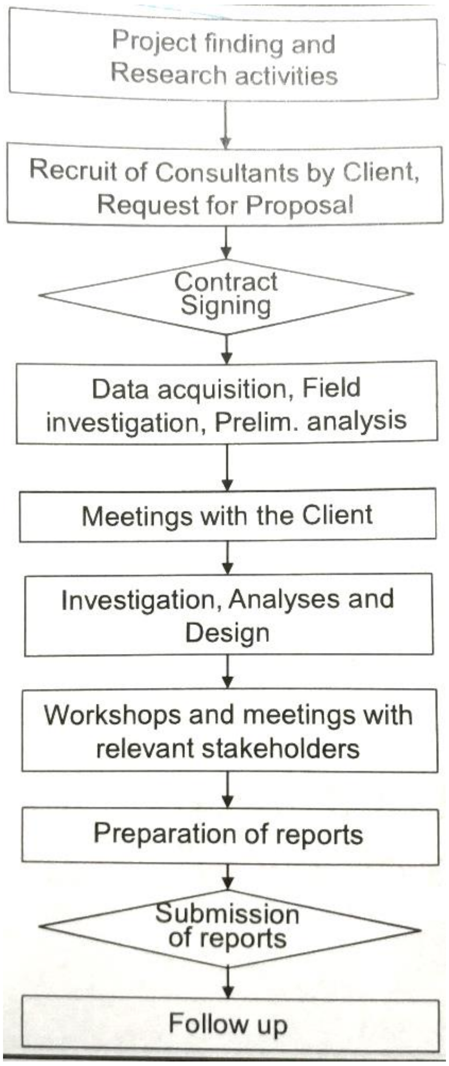

Figure 1-3 Feasibility Studies

1.2 Japan Response to Flood

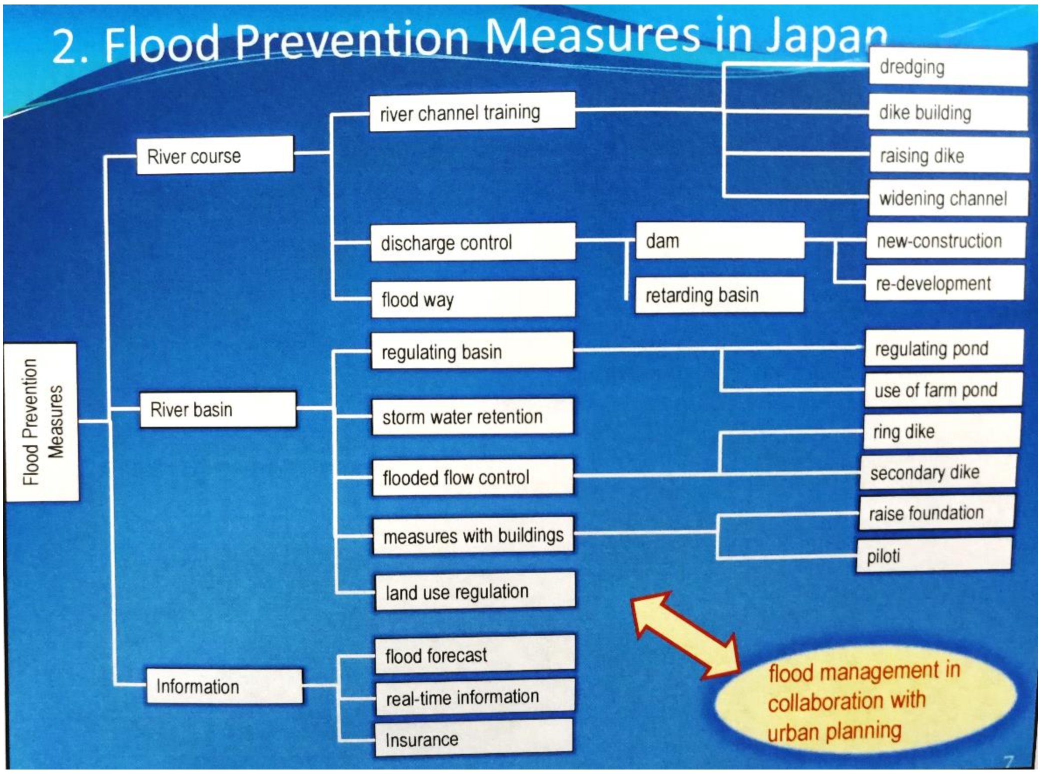

Figure 1-4 Flood Prevention Measures in Japan

1.2.1 Structural measures

Necessary measures shall be taken in priority segments identified along river courses, as well as existing flood control under implementation. The structure of embankment shall be investigated and reviewed to increase the resistance to dike breach when overflow occurred.

1.2.2 Non-Structural measures

- Dissemination of risk information

Publication of flood hazard map for highest target rainfall intensity and resulting flood hazard map with illustration on responses to be taken by residents.

- Preparation and training for evacuation

Timeline of evacuation envisioned and training in role playing.

- Provision of information trigger evacuation

Improvement of flood prediction provision of info., rainfall, river water level, live-image of river, etc.

1.3 NEWJEC's Flood management Technologies

1.3.1 Ground Surface Inundation Simulation

Inundation phenomena due to river overflow, rainfall and runoff are numerically predicted. To be used in damage assessment, planning flood prevention measures, and evacuation methods.

1.3.2 Underground Inundation Simulation

Flood in urban area may result in inundation of underground space (shopping mall, metro, etc.). Limitation in space increases the speed of water rise.

Underground Inundation Model combined with ground surface inundation model enables simultaneous simulation over/under ground which greatly contribute the understanding the phenomena and help evacuation planning. Simulation enables understanding of where inundation starts and to which way it moves on.

1.3.3 Evacuation Simulation

Results used in examining influences of various factors in evacuation process, providing good insight in space/structural design and evacuation planning.

1.3.4 Simulation of River-bed deformation

River bed shape influence the river discharge permissible to flow in the river course. To plan flood control, possible river bed deformation shall be forecast, and necessary measures considered.

Figure 1-5 River-bed deformation

1.4 Experiences

On August 3, 2018 I have a good opportunity to go to internship at NEWJEC company at Osaka. First, I was pleased about the company security. Moreover, they gave a nice lecture to us about flood disaster and mitigation, they also taking about whether how their company works. For instance, the flow work of the consult company to work to government or other firms. Furthermore, we did a group workshop with our group such as group discussion or team working. I got a lot of interested experience from my group members because we come from different country, culture and environmental that made us can knew each other more than only speaking or asking. In group discussion, we discussed about the disaster from our country and the solutions as well. We aimed to do the phenomena in coastal area with countermeasures in the river course, one of the members suggest the countermeasures was called tide gate that was a new thing for me because in my country never had it before. Moreover, I learnt many case that happened in my group's country that I never faced before. This internship is not only doing the workshop or discussion, but also make us to do as a team with each other. Finally, I can talk with Japanese friends quite a lot that make me more understand the culture of this country as well.

1.5 Conclusion & Recommendation

First, in the NEWJEC Inc in which we went to study the process of disaster consultant company. This company, consultant firm, has many part to deal with disaster such as the construction for disaster mitigation and prevention. Furthermore, the company need to deal with other companies and government as well. For these reason, NEWJEC Inc. have to make reports and evidence of study in order to guarantee about their works, especially with Japan Government. Additionally, the process need to prepare for the government as well. These steps of process starting from project finding and research activities until submitting the report of project. The NEWJEC Inc. have a lot of new technologies such as ground surface inundation simulation, underground inundation simulation, and evacuation simulation etc.

From studied at NEWJEC Inc., we learn about the process to work with public firms or government which is quite important things in Thailand as well. Moreover, the new technologies need to use in out country as Japan used.

Chapter 2
Climate Change

2.1 Climate Change Indicators

Ten indicators for a warming world, Past Decade Warmest on Record According to Scientists in 48 Countries, NOA, July 28, 2010 as shown in Figure 2.1. There were 7 indicators increasing and 3 indicators decreasing (Glaciers, snow cover, and sea ice).

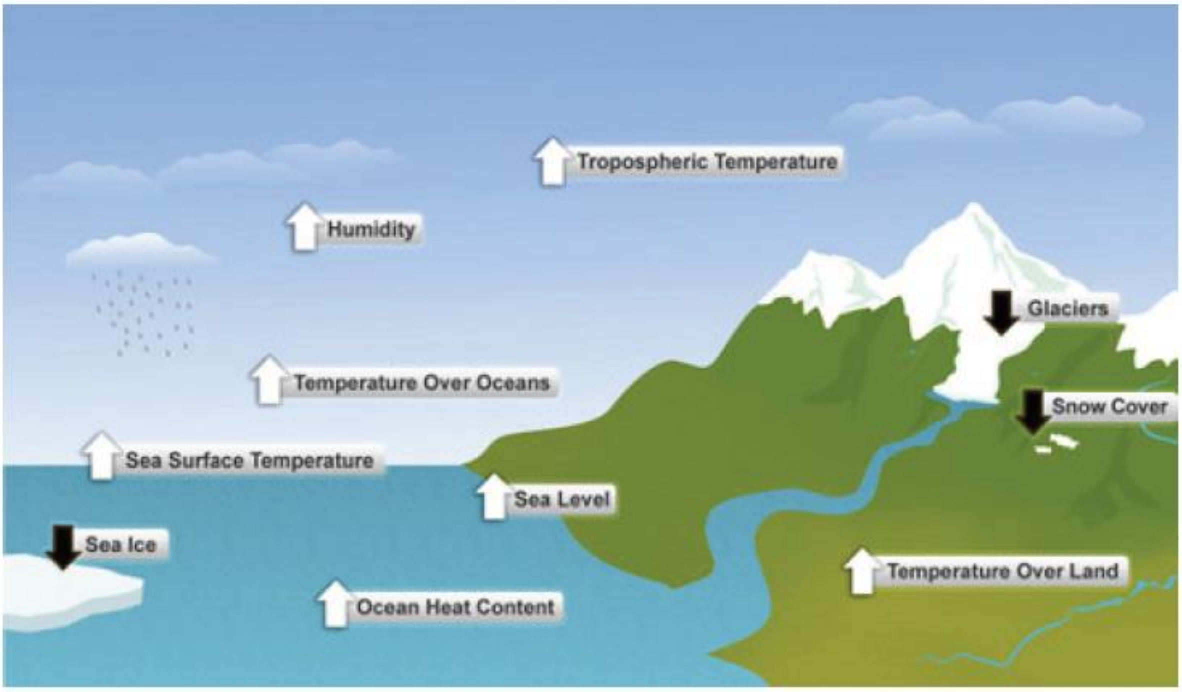

Figure 2-1 Ten indicators for a warming world, Past Decade Warmest on Record According to Scientists in 48 Countries, NOA, July 28, 2010

2.1.1 Sea Level (Ocean warming and Land ice melt)

- Direct observation: Tide gauge (150 years) and Satellite radar altimeters (20 years)
- AR4 and SREX say global climate change is likely cause of sea level rise even with regional variability from non-uniform density change, circulation changes, and deformation of ocean basins
- Long-term sea level rise has decadal and multi-decadal oscillation, but 20th century sea level still more than 19th century.

2.1.2 Ocean Acidification (Ocean uptake of CO_2)

- Observed decrease in ocean pH resulting from increasing CO_2 has significant impact on chemistry of sea water
- Due to the increased storage of carbon by ocean, ocean acidification will increase in future: potentially serious threats to health of world's ocean ecosystems

2.1.3 Ice (amount of ice on land and ocean)

- Summer 2012 lowest Northern Hemisphere sea ice extent on record
- AR4 finds no consistent trends for Antarctica sea ice, but more recent studies indicate a small increase
- Since AR4, improvements in techniques of measurements and understanding of the change

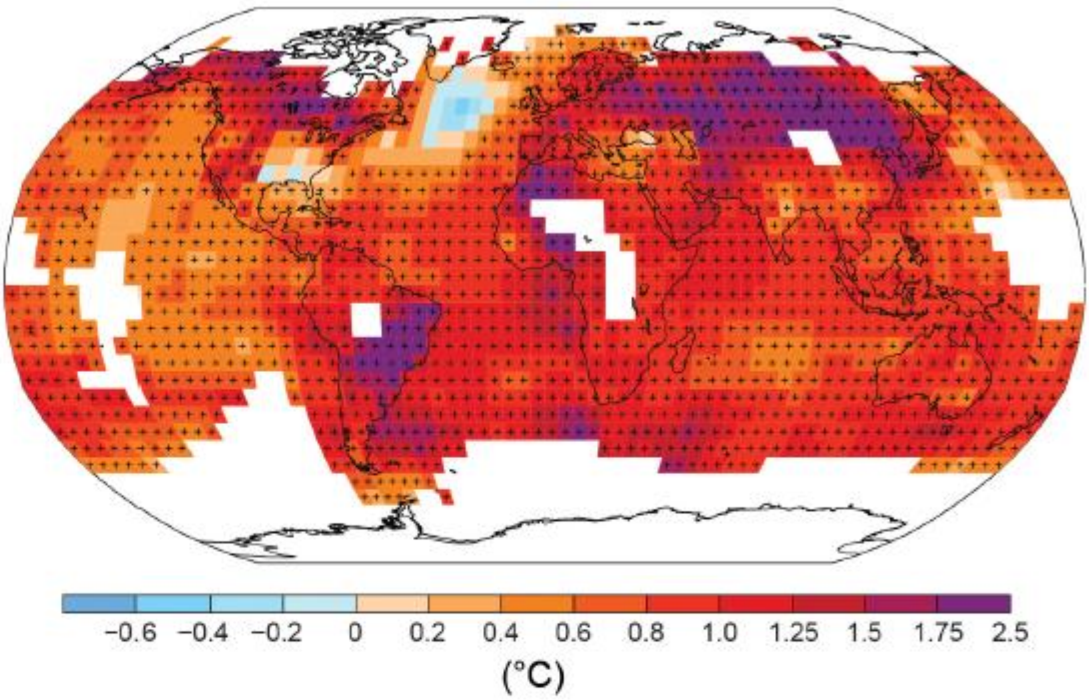

Figure 2-2 Observed change in surface temperature 1901-2012

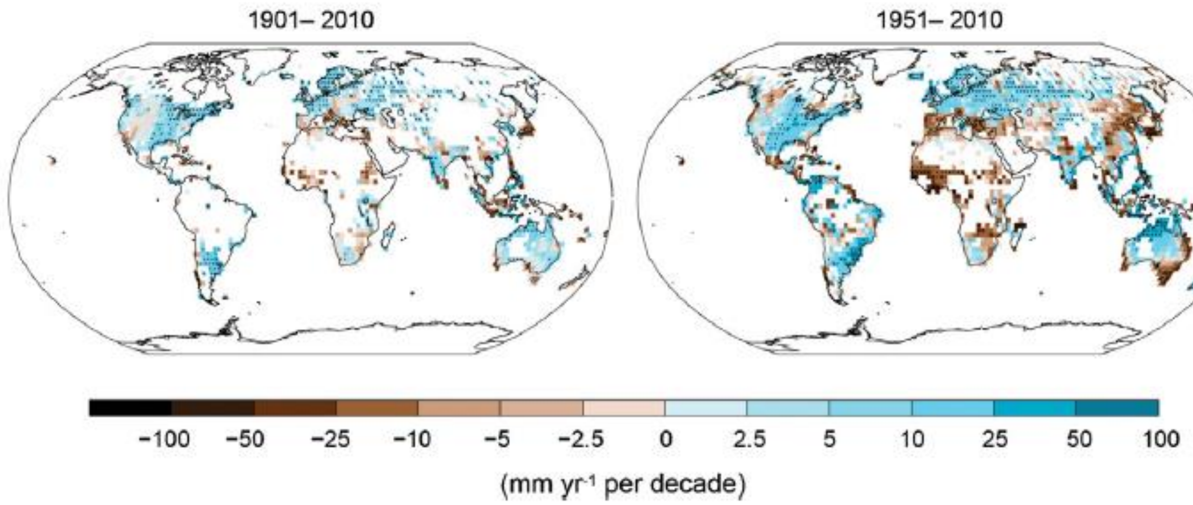

Figure 2-3 Observed change in annual precipitation over land

Changing climate leads to changes in the frequency and intensity of weather and climate extremes. Quantitative definitions for climate extremes:

1) Related to their probability of occurrence

2) Related to a specific (possibly impact related) threshold

Figure 2-4 Climate change inducing, intensifying disasters and extremes

2.2 Climate change impacts and vulnerability

Climate impacts on humans determined by exposure and vulnerability. Vulnerability to climate change is a function of three factors:

Vulnerability = Exposure + Sensitivity – Adaptive capacity

Exposure

- Assets and activities in areas affected by climate extremes
- More subject to hazards

Vulnerability

- Susceptibility of what is exposed to harm
- Capacity for recovery

Increased Exposure and Vulnerability

1) Population Growth

- Changes exposure and vulnerability
- Migration into flood prone areas
- Deficient risk perception

2) Economic Development

- Land use changes
- Altered rainfall-runoff patterns
- Changes to flood frequency and intensity

3) Poor water management practices

- Over-cultivation and deforestation
- Desertification and stress on water system
- Human induced hydrological drought

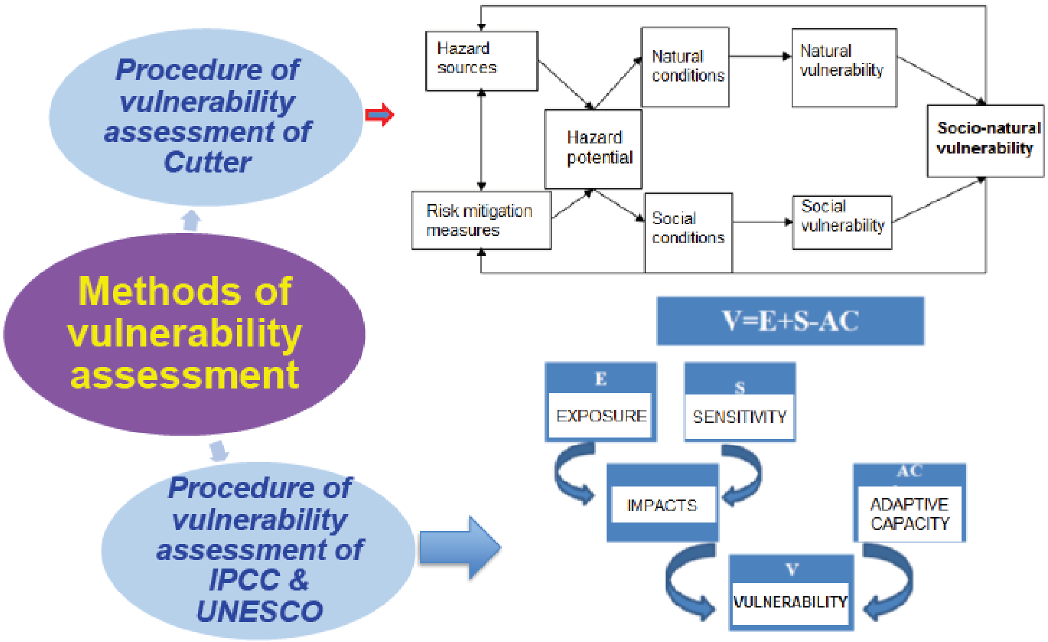

Figure 2-5 Method of vulnerability assessment to climate change

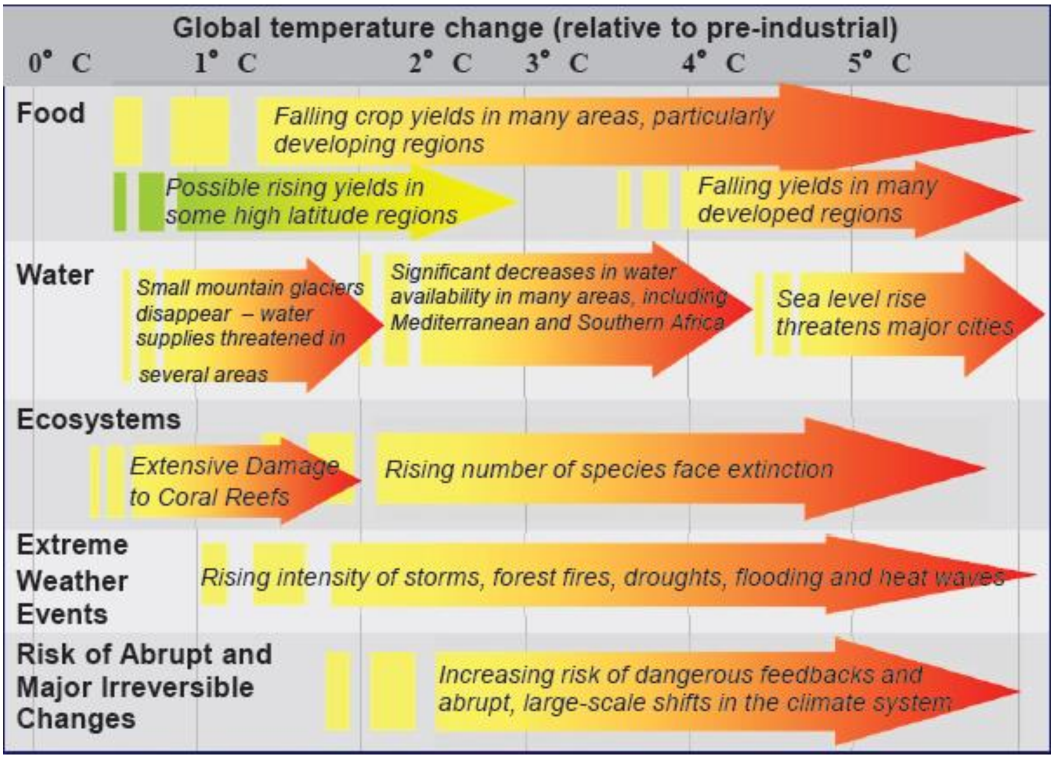

Figure 2-6 Projected impacts of climate change

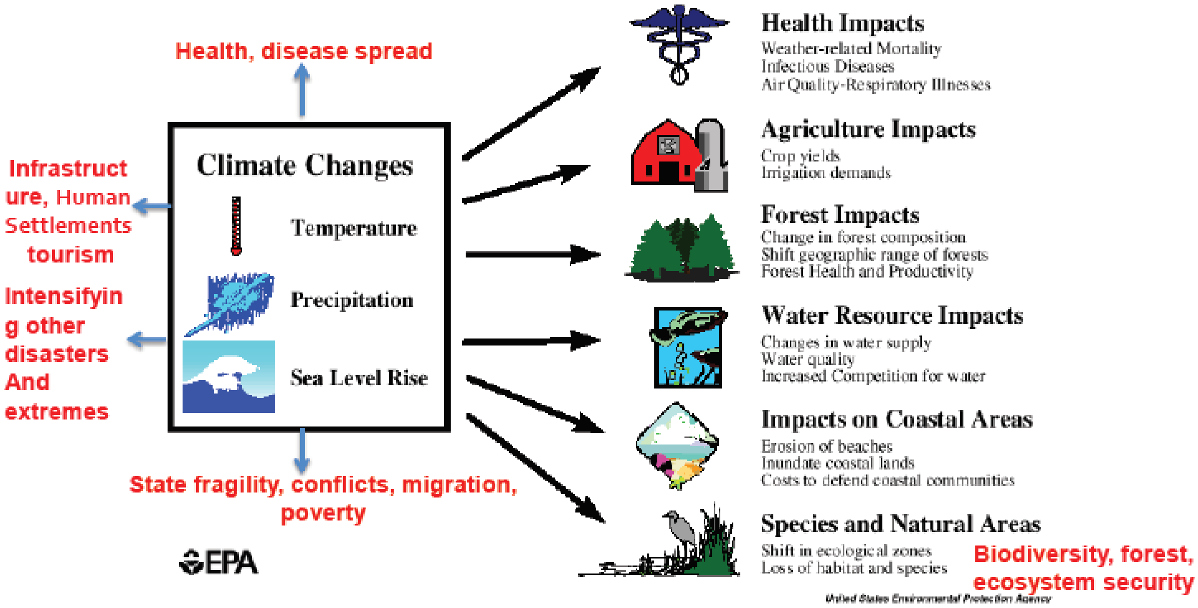

Figure 2-7 Potential climate change impacts

2.3 Climate change response

Climate change is global, but impacts are regional and local. Impacts will affect different communities differently based on their specific circumstances. Therefore, solutions must be locally specific:

1) Integration of modern knowledge, technologies, indigenous knowledge, and experiences of the local community

2) Nature, ecosystem based climate change response

3) Community based climate change response community-driven, grass-roots component of climate change response, responding to locally specific and global needs, developing lessons for global and national stakeholders to further adaptation practice

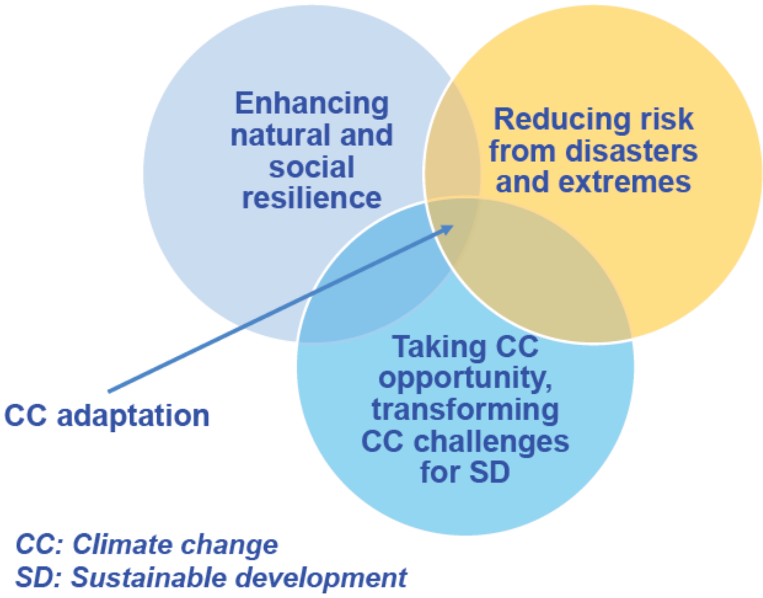

Figure 2-8 Climate change adaptation

2.3.1 Climate change adaptation

- Reducing negative impacts, or enhancing positive impacts of climate change
- Local, short-term to long-term
- Emergency management and disaster mitigation
    - Accounting for increased frequency and severity of climate/weather related extreme events
    - Enhancing resilience to these events

2.3.2 Climate change mitigation

- Limiting warming to 2°C is possible but involves substantial technological, economic and institutional challenges.
- Combination of adaptation and substantial, sustained reduction in GHG emissions can limit climate change risks.
- Ambitious mitigation is affordable: economic growth reduced by 0.06%. Estimated costs do not account for the benefits of reduced climate change
- Mitigation cost estimates vary, but do not strongly affect global GDP growth.

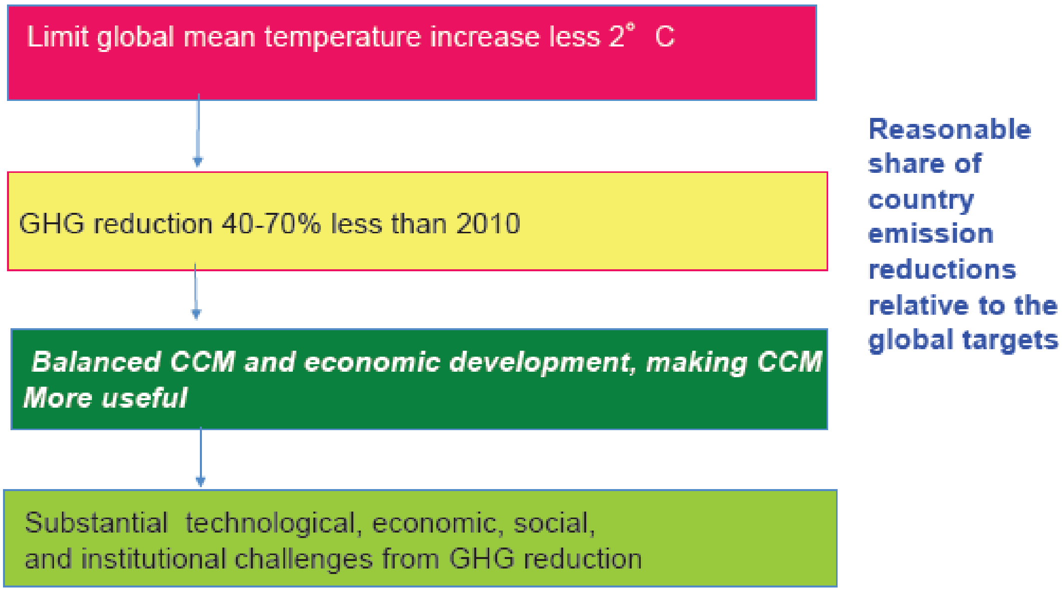

Figure 2-9 GHG Mitigation Goals

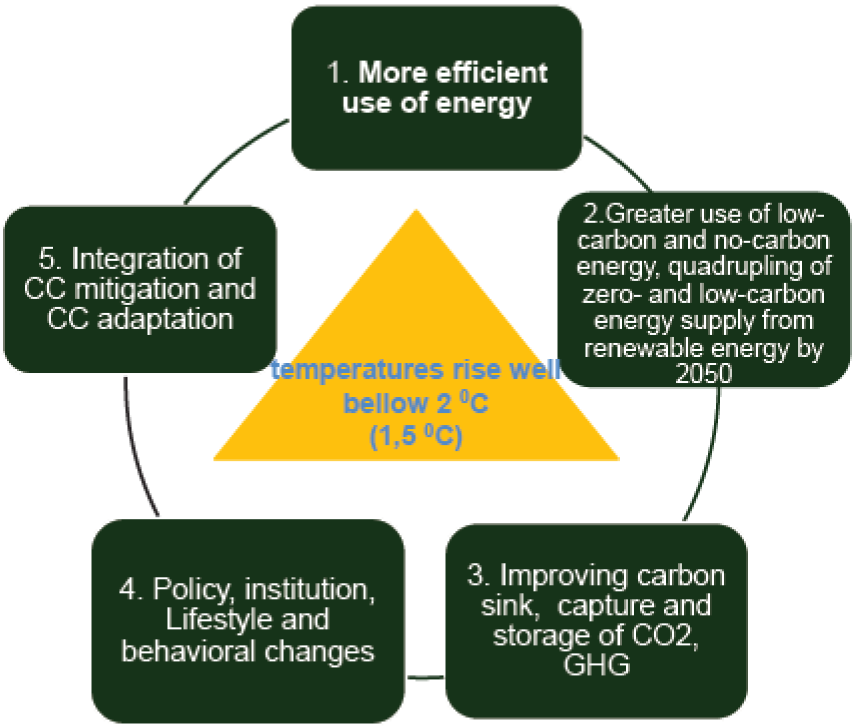

Figure 2-10 Using the low carbon solutions to model climate change mitigation goals

2.3.2.1 Mitigation activities

– Develop Nation Appropriate Mitigation Actions (NAMAs) and Intended National Determined Contribution (INDC), National determined Contribution (NDC)

- Reduce demand for energy-intensive goods and services
- Expand use of low and zero carbon energy sources
- Build the low carbon society
- Integrate the climate change mitigation sustainable development

2.3.2.2 Technical Options Available

- Increased energy efficiency
    - Building design and systems
    - Industrial processes
    - Transportation systems
    - Electric power systems
- Low-carbon electricity
    - Renewables: wind, hydro, geothermal, solar
    - Nuclear power
    - Coal and gas
    - Natural gas
- Decarbonized fuels
    - Biofuels based on LCA emissions
    - Hydrogen from renewables, nuclear, natural gas, and coal
    - Synthetic fuels from coal, natural gas, biomass, oil sands
- Replace fuels with low-carbon electricity
    - Grid-charged batteries for ground transportation
    - Heat pumps for building furnaces and boilers

2.4 Case study of one of the most vulnerable countries but pioneering in climate change response: Vietnam

2.4.1 Natural and socioeconomic conditions

1.1) Natural conditions are sensitive to climate change negative impacts.

- 2/3 territory is mountainous: strongly dissected

- High differentiation of natural conditions
- Abundant coastal lowlands, flooded areas arid regions
- Long Coastline, over 3,260 km: every 10 km has one river mouth
- Nearly 65% of Vietnam’s surface water resource from overseas
- Water shortage has used approximately 40% of water source, approximately ecological safety threshold recommended by the FAO

1.2) Socioeconomic conditions

- Minority and poor people habited in the areas very sensitive to climate change and disasters
- Main production sectors: agriculture, fisheries, and forestry are much dependent and vulnerable to the impact of climate change
- Level development of science and technology, technical and socio-economic infrastructures lower than requirements to respond to climate change
- High population density, low income
- Fast urbanization

2.4.2 Disaster and Extreme events in Vietnam

In Vietnam, there are disasters and extreme events related to climate change.

2.1) Drought

- Increased in number and magnitude, particularly, Central, highland and Southern areas
- River water level quickly decreases

2.2) Flood

Highly vulnerable areas are Red river delta, Mekong delta, Riverine estuaries of Central area. (Monre, 2012)

- Red River delta: Reduction of the annual flow, big floods occurred frequently in the upstream.
- Mekong River delta: Witnessed many floods, especially in 2000, 2001, 2011, with the water level of over 4.5 m.

- The Central Vietnam: Occurred very fast and dangerous

Figure 2-11 Flood in Vietnam

2.3) Other extremes

- Cold days in the North decrease
- More extreme cold days
- Unseasonable rain and abnormal heavy rainfall more frequent
- El Nino/La Nina have impact stronger

2.4.3 Impact of climate change on water resources in Vietnam

- Sea level rise will increase salinity in the river.
- A sea level rise of 1 m would increase the area of 4 g/l salinity with 334,000 ha in relation to the benchmark year of 2004, a rise of 25%.
- Water pressures drop by 2-5 m in the dry season.
- Groundwater use is depleting limited aquifer and further intensification of groundwater use is unsustainable.

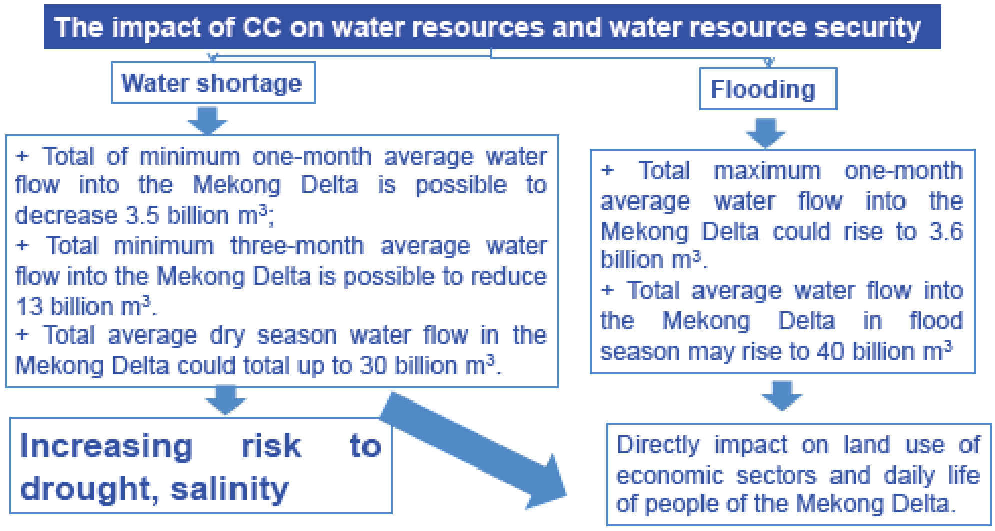

Figure 2-12 Impact of climate change on water resources and water resource security

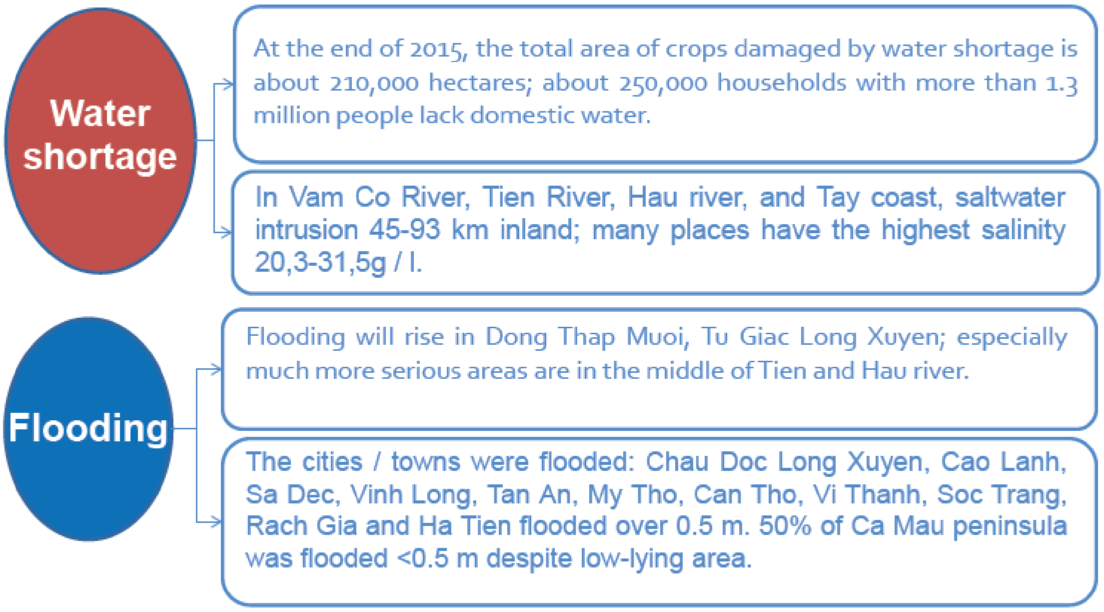

Figure 2-13 Impact of climate change on water resources and water resource security (Monre, 2015)

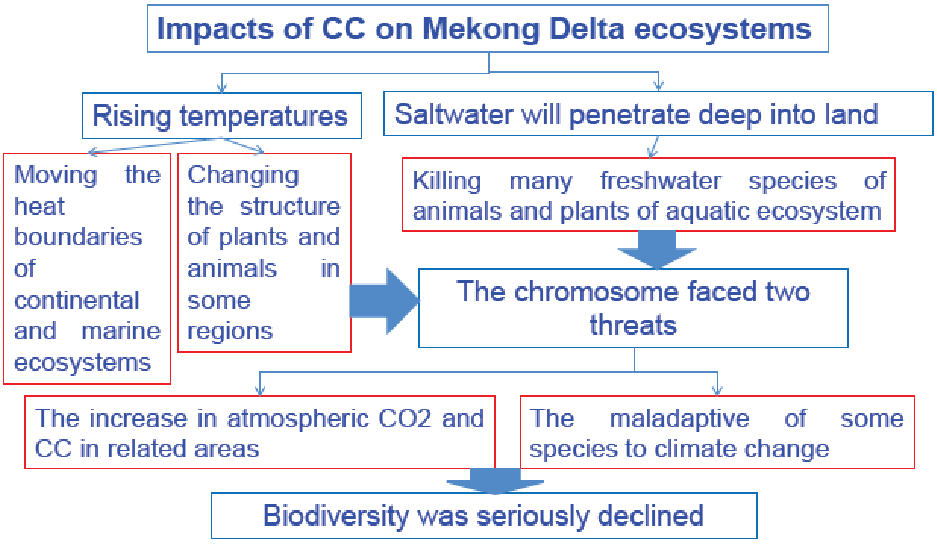

Figure 2-14 Impacts of climate change on Mekong Delta ecosystems

2.4.4 Climate change response in Vietnam

- Climate change response science, technology achievements, Climate change scenarios based
- Development, integration of policy and institution on climate change response, including green growth strategies, NMA, INDC into development policies, strategies
- Promoting social power to climate change response
  - Living with floods

Figure 2-15 Living with floods

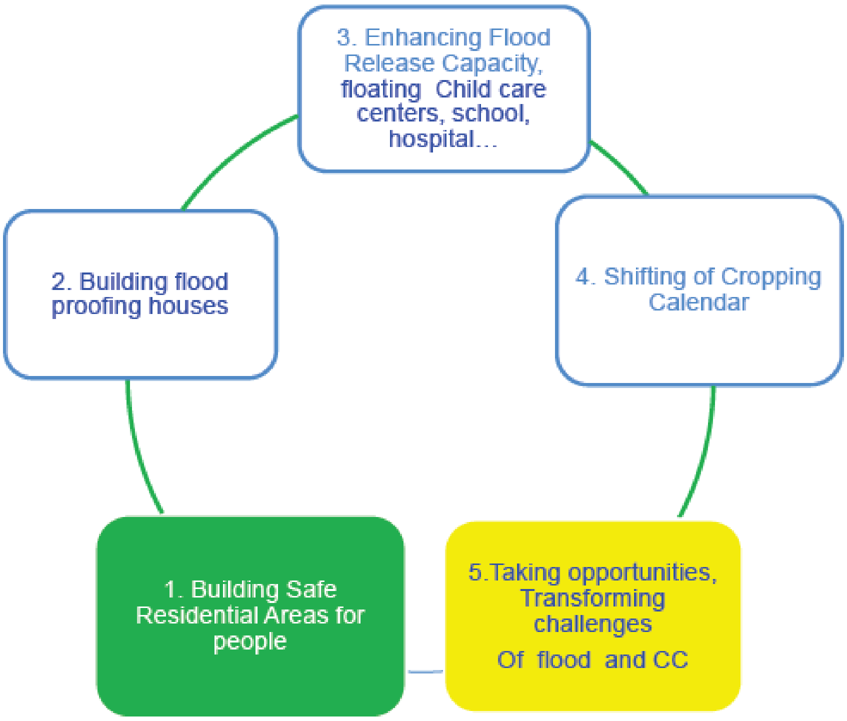

Figure 2-16 Living with floods

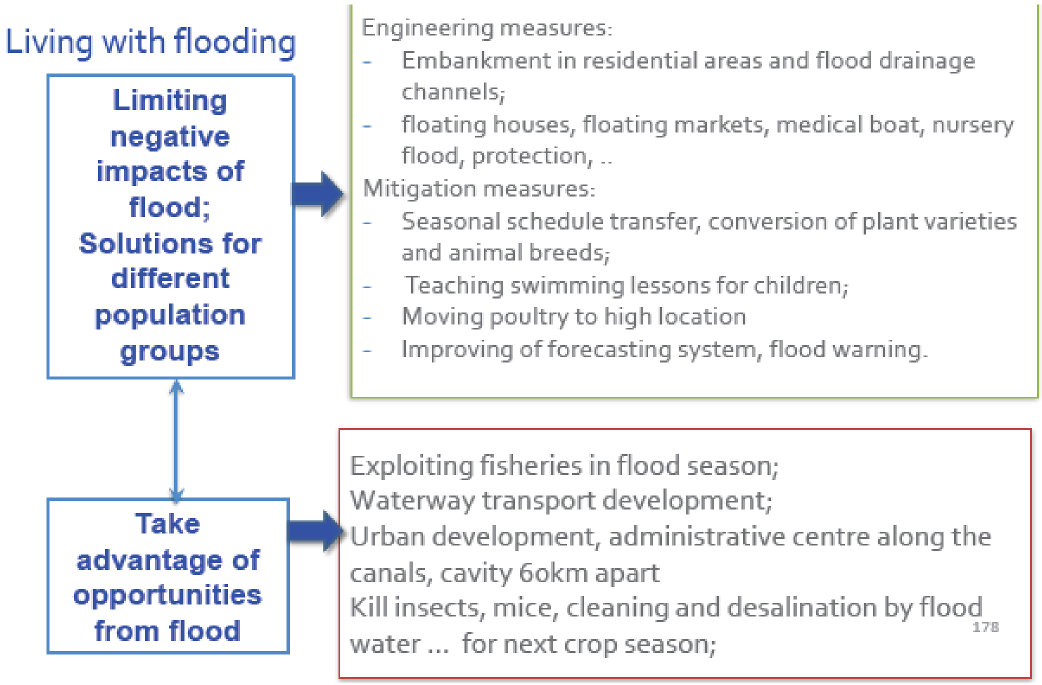

Figure 2-17 Living with floods

– Living with drought

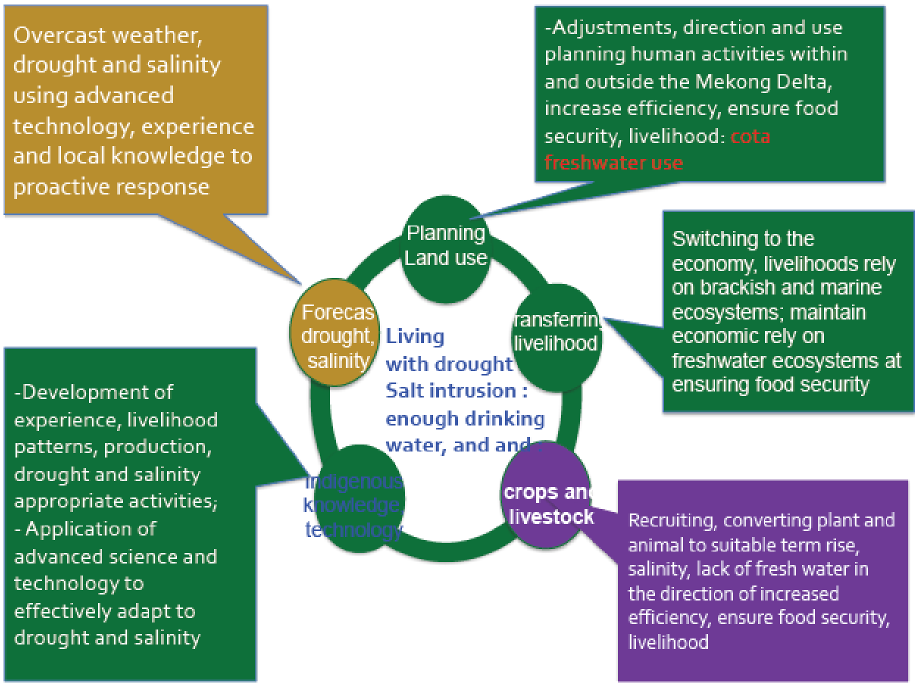

Figure 2-18 Living with drought

– Living with climate change: Climate change adaptation, climate change mitigation

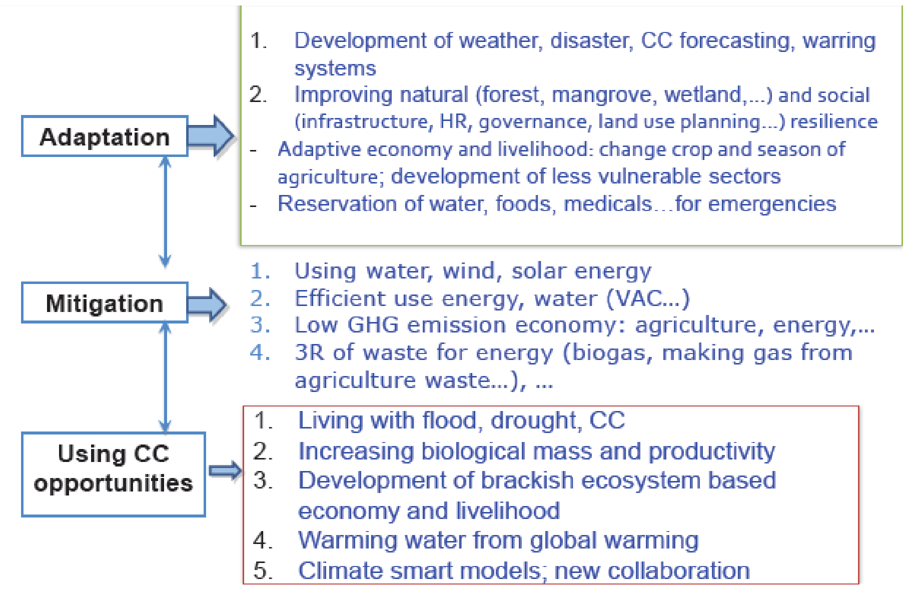

Figure 2-19 Living with climate change

- Proactively response to natural disasters and climate change through resource sustainable use planning based on vulnerability assessment

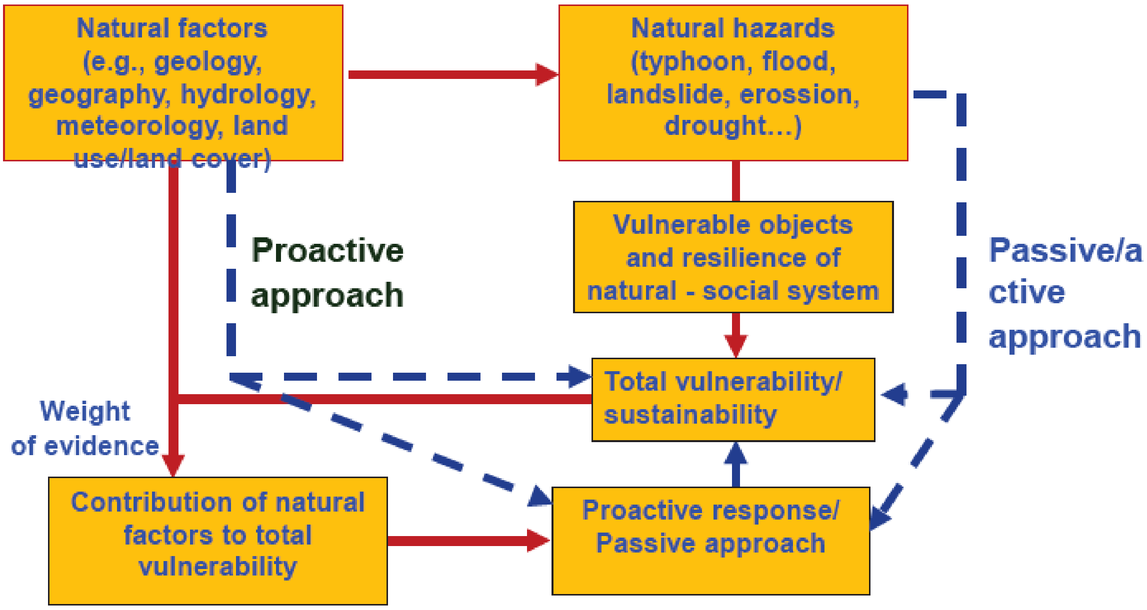

Figure 2-20 Passive and proactive approaches in disaster and vulnerability assessment, reduction for sustainability

- Effective development and improvement of international cooperation to climate change response
- Development of human, financial resources for climate change response
- Developing science and technology for climate change response

2.5 Impact and vulnerable by climate change

Nowadays, impact and vulnerable by climate change tend to be serious topic in our world. There are many impacts that relate to human life:

1.Health impacts

2.Agriculture impacts

3.Forest impacts

4.Water resource impacts

5.Impacts on coastal area

6.Species and natural area

Such a professor lectured in class, we got many evidence and appearance in our world such as temperatures, precipitation or sea level rise. These evidences and appearances we got to analyze or to compare with the past in order to look the trend that happened in the world. As I studied with professor, there are some analyze data displayed into pie charts such as number of disasters, loss of human life, and economic losses. For number of disasters in global, flood is the most disaster which happened more frequent in the world. However, loss of human life and economics loss which the most cast is not flooding, but it is drought and windstorm respectively.

For my country that in the Asia area, the impact and vulnerability tend to increase more than other area. Thailand is in the tropical zone that near the equator line of the earth. There are many unpredictable phenomena occurring in this area. Moreover, the weather is tending to increase extremely as well, especially in the summer season in Thailand has temperature more than 40 Degree Celsius.

For instance, the huge flood in Thailand in 2011, it got the economic losses more than 40 billion dollars because the climate change made some disasters occurred irregularly. In this case study, we got 5 typhoons in 3 months, but the last 3 typhoons were coming within 2 weeks. These typhoons came in Thailand in the short time period, then we cannot manage or warning on time.

Furthermore, in case of water resources in my country, as professor mentioned in class we face the problems in water resource that tend to increase too much. These water supply tend to increase every year that come from typhoons in Thailand. Moreover, not only water resource is the serious topic that effect from climate change, but the GDP per capita and vulnerability are important topics as well. Such an increasing temperature due to climate change, we got a lot of impact from them such as agriculture yields tend to decrease, health or people living is not normal and disasters occurring.

For 6 impacts that I mentioned previously, First, health impacts happened to people in Thailand such as the weather is changing cycle, higher temperatures and infectious diseases. Second, agriculture impacts happened almost in rural area because effect from disasters such as flood or drought that make crop yields damage or reduce products. Third, forest impacts cause some area in the northern part of Thailand having burned down. Fourth, water resource impacts that I mentioned before in water supply and effect a lot of flood. Fifth, impacts on coastal area, some area such as Bangkok which is the capital city of Thailand is near the gulf of Thailand. In this area is facing a problem about high sea water level that impact to inundation in city. Last, species and natural area, for example some area facing with many disasters due to climate change that will effect on the habitat of wild life, and sometimes it can cause the main point of intinction of some species.

These impact and vulnerability by climate change is the main serious topic in our world especially Thailand and Asia area that effect in these phenomena too much. So we know the evidences or appearances of climate change that effect on our life such as disasters, we have to improve mitigation system for climate change immediately as fast as possible. In my opinion, we should consider about climate change and adapt, living or mitigation with climate change.

2.6 Conclusion & Recommendation

Climate change is a serious issue in the present. Many countries affect from climate change which including extreme temperature, flooding, drought, typhoon, and earthquake etc. Climate change happened every era from the past, the evidence that identify effect from climate change are the changing or phenomena in the global. This changing makes the people in the world affect, not only living in the area, but the dangerous including as well. Nevertheless, climate change is not simply disadvantage to human, but also make some advantages to human. For instance, in the northern part of the world, Russia, generally is the ice-land-cover area which cannot growth ant plant in the area. However, after effect on climate change which makes this area warmer than the previous, and they can do agriculture which make the income into their country. Nowadays, we have some solution that lived with climate change or adapt to live with this disaster.

For Thailand case, climate change effect on the extreme temperature in the main issue. Not only the extreme season, but the pattern of rainfall including as well. The pattern of rainfall is changing in Thailand which make the extreme disaster occur to the country such as more frequent flooding or drought. These disasters happened a lot in Thailand and making the economic loss and social loss.

Chapter 3

Countermeasures against Natural Disasters Based on Human Diversity

Generally, as a nation or region is increasingly developed and improved, the demand for social systems based on residents' diversity rises. This trend appears not only at normal times but also during emergencies. In this section, we describe countermeasures against natural disasters based on the diversity of local residents. "Diversity of residents" means the coexistence of people with various characteristics and values, such as aged people, people with disabilities, women, foreigners, and laity of various religions. We consider countermeasures to protect people in need of care by studying the current status and countermeasures of Japan, which is a disaster-prone country and one of the countries with the most effective countermeasures against natural disasters.

During the Great East Japan Earthquake in 2011, the fatality rate of aged people was higher than those of other age group (Figure 3.1), and that fact made the Japanese people strongly aware of the necessity for countermeasures to protect aged people. On the other hand, to ameliorate the labor population shortage, the possibility of accepting foreign laborers is now being discussed. Therefore, we describe countermeasures for especially aged people and foreigners in this section.

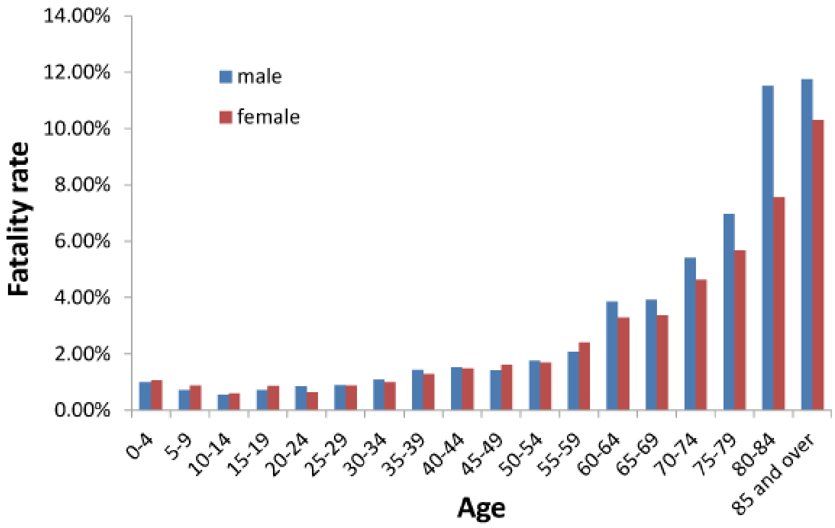

Figure 3-1 Fatality rate of three prefectures extensively damaged by the Great East Japan Earthquake (Iwate, Miyagi, and Fukushima) by age group

3.1 Aging and Countermeasures against natural disasters

In the world, many countries' populations now trend to be aging due to longevity brought about by improved medical services and public sanitation, and due to declining birth rates brought about by social structure changes. Japan is one of the countries that are aging most rapidly aging in the future (Figure 3.2).

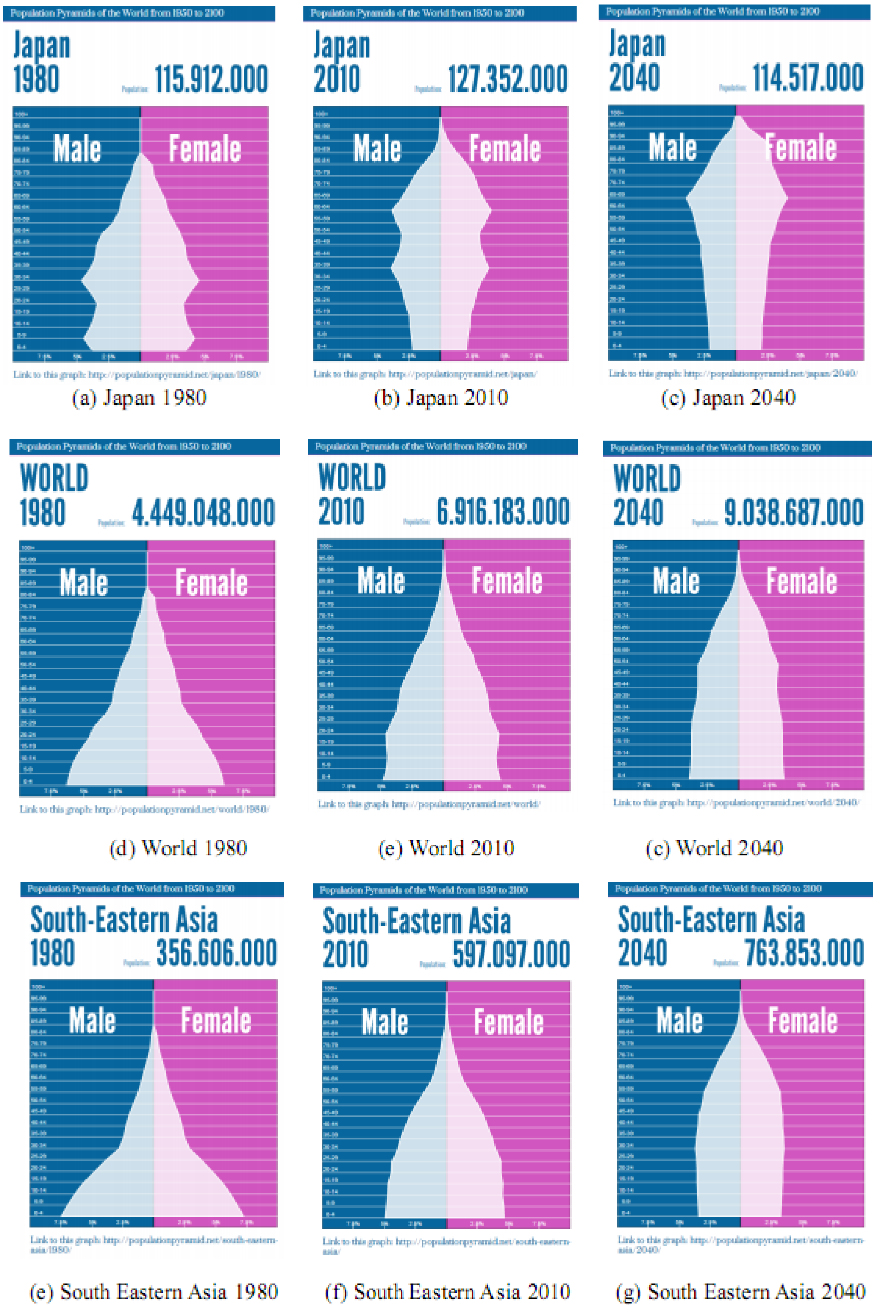

Figure 3-2 Population pyramid (Extracted from the site: http://populationpyramid.net/)

According to the United Nations' estimate, other Asian countries will also be rapidly aging in the future. As we get older, our bodily functions and cognitive functions deteriorate. Aged people cannot maintain bodily functions and cognitive functions, and when they lose those functions required for caring for themselves, they need nursing care services in their daily lives. As indicated by Figure 3.3, which shows the relation between age and certification rate of long-term care need, the certification rate of long-term care need increases rapidly as age goes up. Especially, those 80 years old show much higher rates of requiring long-term care than other groups.

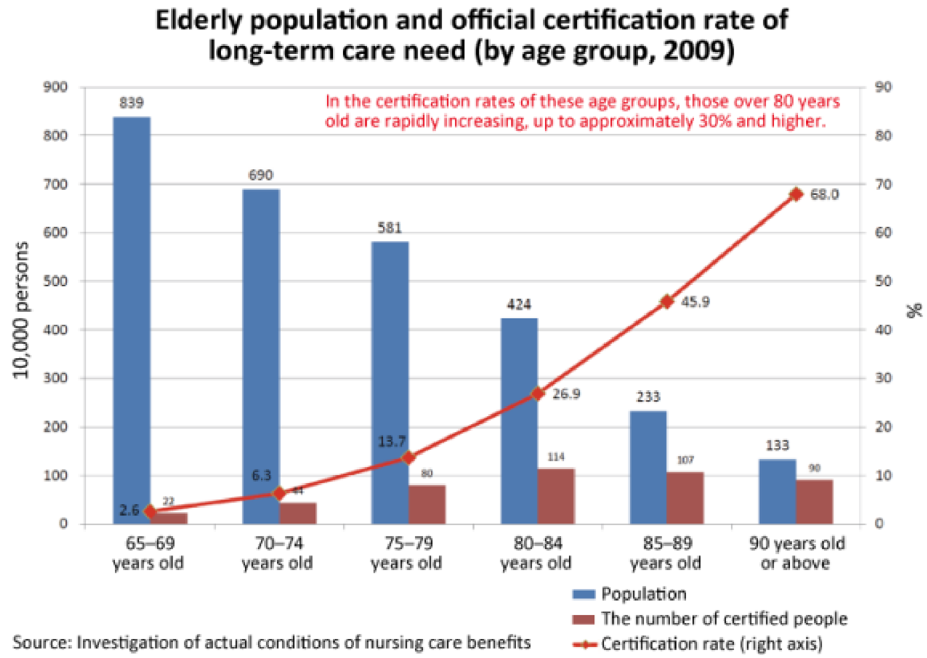

Figure 3-3 Japanese elderly population and official certification rate of long-term care need (Ministry of Health, Labour and Welfare)

With the rapid aging of society and a reduction in the number of children, facilities for social welfare for the aged in Japan cannot receive all of the people need long-term care ; even if a sufficient number of facilities are built for rapidly for a short period because a decrease in overall population will become more acute in the future. The Japanese government is taking steps to let people who need long-term continue living at their residence with promotion of in-home nursing care service.

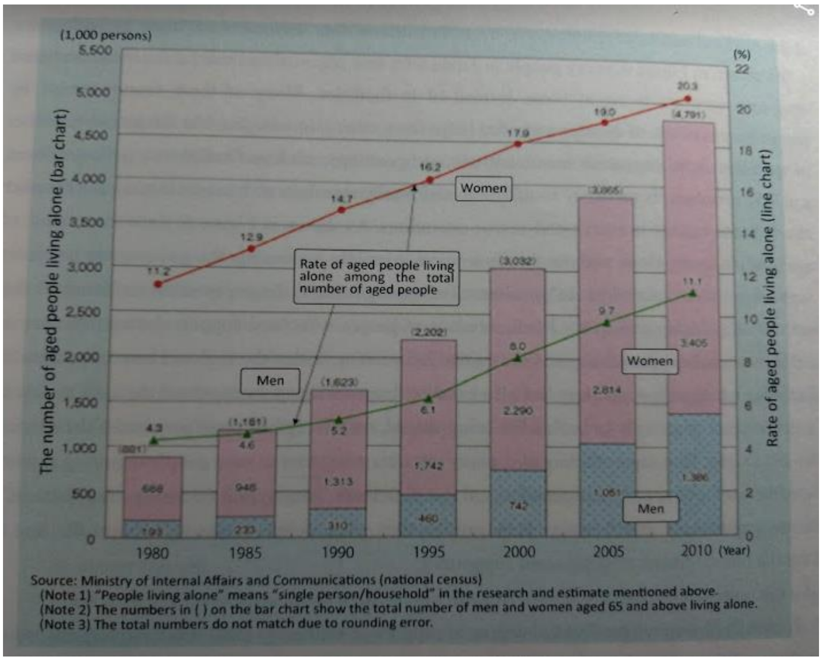

Figure 3-4 Trend of aged people living alone

Japan is a disaster-prone country, and as such, is promoting the improvement of earthquake-proof structures and development of embankments and river environments. It is one of the countries with the most effective countermeasures against natural disasters. However, the reduction of tax revenues due to the depression for the last 20 years and reduction of human resources due to rapid population aging make it more difficult than in previous times to enhance hardware, especially structures. Therefore, the importance of software-oriented countermeasures focusing on human behaviors, such as self-help and cooperation of residents, is increasing. As mentioned above, the number of people requiring support within the region is now rapidly increasing. Accordingly, the necessity of software-oriented countermeasures is increasing further.

In truth, support for aged people in a time of disaster is an on-going task in Japan. We consider our national policies for useful countermeasures. This section describes two topics: evacuation centers and temporary housing.

In Japan, elementary school gymnasiums are often used as evacuation centers (Figure 3.4), but they do not provide comfortable living environments for aged people. People who need nursing care cannot live independently in such evacuation centers. Therefore, they have to find other places such as relatives' houses or facilities in area other than the damaged areas, or evacuate to welfare evacuation centers (Figure 3.5). "Welfare evacuation center" is an existing building used as an evacuation center equipped with portable toilets for people requiring support, hand rails, temporary slopes, and other barrier free living environments, where people who find difficulty living in ordinary evacuation centers, including aged people who need nursing-care and members with disabilities, can receive care.

Figure 3-5 Evacuation center during the Great East Japan Earthquake

Figure 3-6 Welfare evacuation centers

3.2 Foreigners and disaster prevention measures

The number of foreigners visiting Japan in 2012 was 8,358,105 from Japan National Tourist Organization (JNTO). The main challenge for foreigners during a disaster is language. For foreign victims of the Great East Japan Earthquake, the Japan Center for International Exchange operated multilingual information services and assistance services, and visits to the evacuation centers. Generally, the Japan Center for International Exchange and International Association are affiliated organizations of each prefecture or municipality, and conduct tasks related to internationalization in the relevant areas.

For transients like tourist who do not know the relevant disaster relief locations, we have to ensure their safety, provide evacuation locations and goods, support safety confirmation, and assist them in returning to their homes, in addition to language support. Kyoto City is one of the biggest sightseeing spots in Japan, and not only Japanese but also many international tourists from various countries visit there.

Currently, the Kyoto City government prepares an “Escape guiding plan for travelers who have difficulty in returning home” for two area that receive many tourists (Kiyomizu-Gion and Saga-Arashiyama),and is promoting support for travelers who have difficulty in returning home. However, actual support for foreign tourists is just beginning now. Although the multilingual or simple Japanese information services are mainly provided by the International Association, it is difficult to provide the necessary information to transients who have no knowledge of Japanese disaster relief processes.

3.3 Group work (Emergency response plan for foreign student)

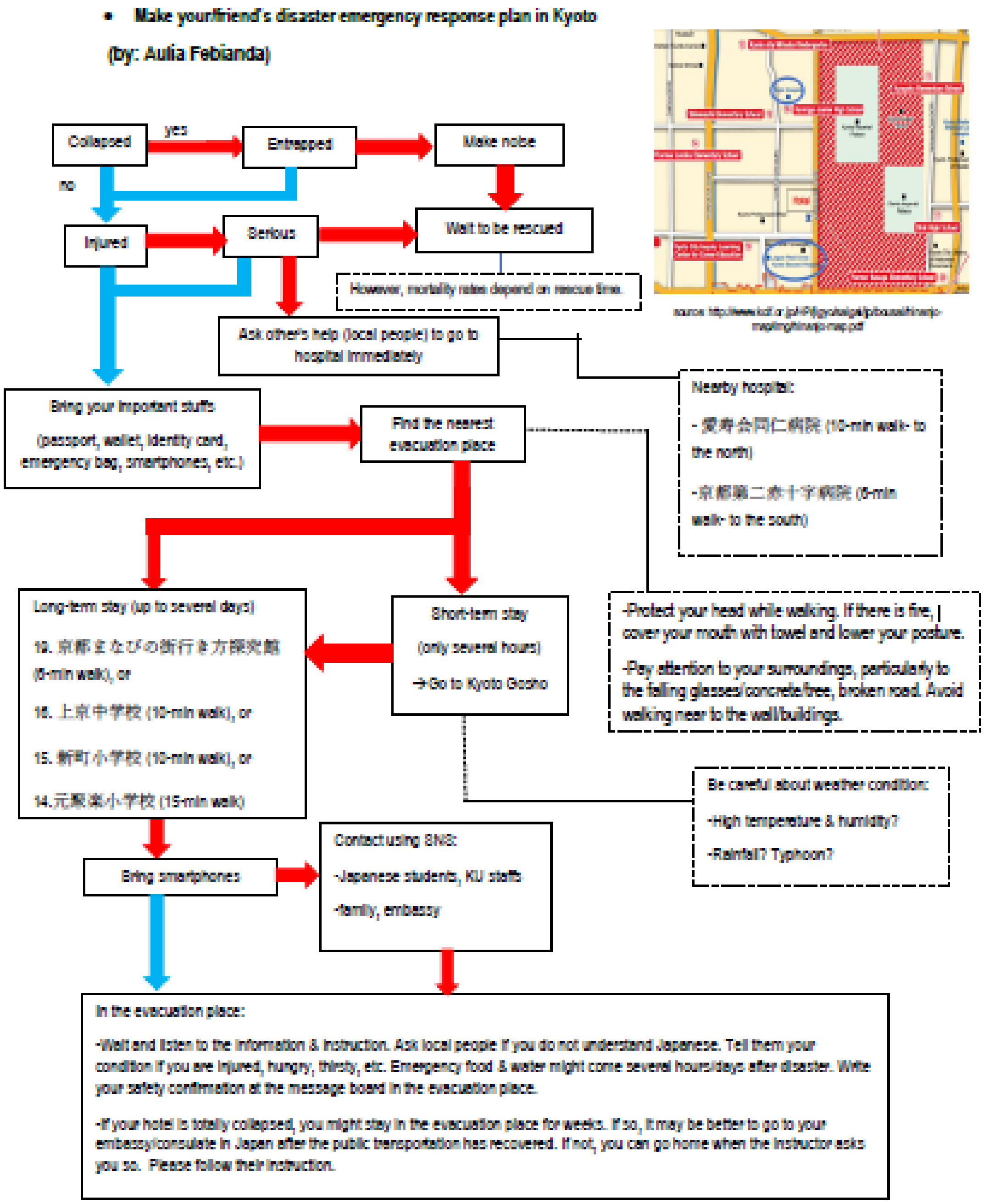

Figure 3-7 Emergency response plan for foreign student

3.4 Example of Natural Disaster in Thailand.

In 2011, Thailand got a very big flooding in Chaophraya river basin. This disaster is ranked by the world bank that is the 4th rank of the economics loss in the world. A lot of industrial park was under the water including many Japanese company. This disaster results from 5 storms flow through the northern part of Thailand. Government set the criteria that if we get 1 storm through our country, it will be a dough year. If we get 2 storms through our country, it will be a normal year. And if we get more than 2 storms, it will be a flooding year. In 2011 between June to July we got only 2 storms, so the government kept the water in reservoir for the next summer. However, between September to October we got more 3 storms. So, the reservoir could not release water for preparing enough storage for these 3 storms. This situation causes from changing in frequency of storm which is the result of climate change. This disaster effect on 65 provinces in northern and center part of Thailand with 813 deaths. Around 13 million got the effect from this disaster and the economics loss is around 40 billion (US$).

Figure 3-8 Thailand Flood 2011

After this disaster, government help the victims by finding some place such as school, university, temple and official place for living during disaster. Moreover, some government agency provided some welfare for the victims. For example, the metropolitan waterworks authority and the provincial electricity authority delayed the payment of victims in this disaster. There is some government agency give money to the victims such as Department of

Disaster Prevention and Mitigation. However, in long term, the government designs for the effective forecast model, warning system and water management in our country.

3.5 Conclusion & Recommendation

This chapter is talking about Countermeasures against Natural Disasters Based on Human Diversity and the different of age such as aged people, people with disabilities, women, foreigners, and laity of various religions. We should learn from Japan because they are one of the countries with the most effective countermeasures against natural disasters. Because of Japan is one of the countries that are aging most rapidly aging. They have to prepare and separate victim who suffer from disasters. Japan prepare to take care who is the old age and need long term by The Japanese government is taking steps to let people who need long-term continue living at their residence with promotion of in-home nursing care service. And when the disasters comes. Japan prepare the places such as school, gymnasium to be the evacuation center and then separate people who have different age and send to the suitable place.

In my opinion, we can use the knowledge from Japan to manage when Disasters occur in Thailand for example when Thailand got flooded. We would know who are the victim and help them first.

Chapter 4

International/National US&R systems in UN, US, UK and Japan

Urban Search and Rescue (US&R) is issue in disaster preparedness, management and response. Multidisciplinary US&R operations, involving search (location), rescue (extrication), and initial stabilization, are needed to save the lives of victims trapped in structures or buried in debris at sites of catastrophic disasters.

On-site medical stabilization and other medical treatments, provided to trapped patients dark, hazardous, dusty and confined sites inside collapsed structures, is called confined space medicine (CSM). CSM is conducted in conjunction with confined space rescue (CSR) teams that are capable of operating in structural collapse disaster. CSM/CSR operations are conducted as part of the entire US&R operation and require highly specialized knowledge and techniques. Therefore, to build multidisciplinary teams capable of operating effective, efficient and safe rescue operations are demanded, and training would be the key to build such teams.

4.1 National US&R response system in USA

4.1.1 Overview

In 1980's, the Federal Emergency Management Agency (FEMA) established the National Urban Search and Rescue (US&R) Response System in 1989 as a framework for structuring local emergency services personnel into integrated disaster response task forces. In 1991, the Federal Emergency Management Agency (FEMA) incorporated this concept into the Federal Response Plan, sponsoring 25 national US&R task forces.

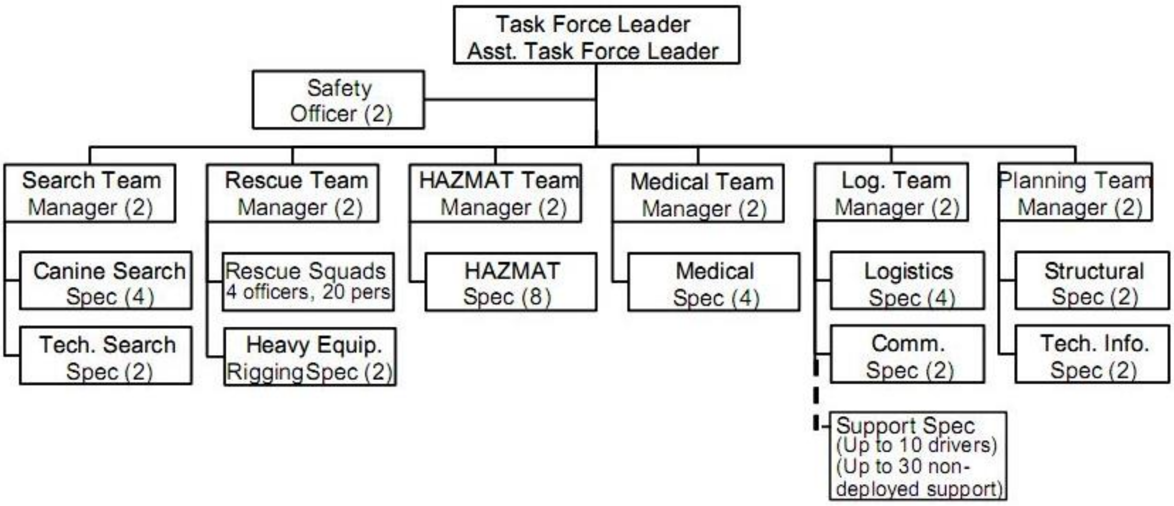

Figure 4-1 US&R task force team organization chart

Today there are 28 national task forces staffed and equipped to conduct round-the-clock search-and-rescue operations following earthquakes, tornadoes, floods, hurricanes, aircraft accidents, hazardous materials spills and catastrophic structure collapses. These task forces, complete with necessary tools and equipment, and required skilled and techniques, can be deployed by FEMA for the rescue of victims of structural collapse.

4.1.2 National Response Framework Emergency Support Function

National US&R response system is a component of the National Response Framework (NRF), Emergency Support Function (ESF), and NRF is a guide to how the nation conducts all-hazards incident management.

In 2003, President Bush issued Homeland Security Presidential Derective-5 to develop and administer a National Incident Management System (NIMS). This system represents a core set of doctrine, principles, terminology, and organizational processes that enables effective, efficient, and collaborative incident management. NIMS and the NRF are designed to improve the Nation's incident management capabilities and overall efficiency. During incidents requiring coordinated Federal support, the NRF provides the guideline and procedures to integrate capabilities and resources into a cohesive, coordinated, and seamless national framework for incident management.

4.1.3 Position qualifications

Training is critical to FEMA National US&R Response System Preparedness. Two categories of training are within FEMA National US&R response System: General training required for all task force members and position-specific functional training applicable to particular task force positions.

4.1.4 US&R training

FEMA courses an other training that the level of NFPA standards are held at training sites. Figure 8 is an example of list of search and rescue training couses in Texas.

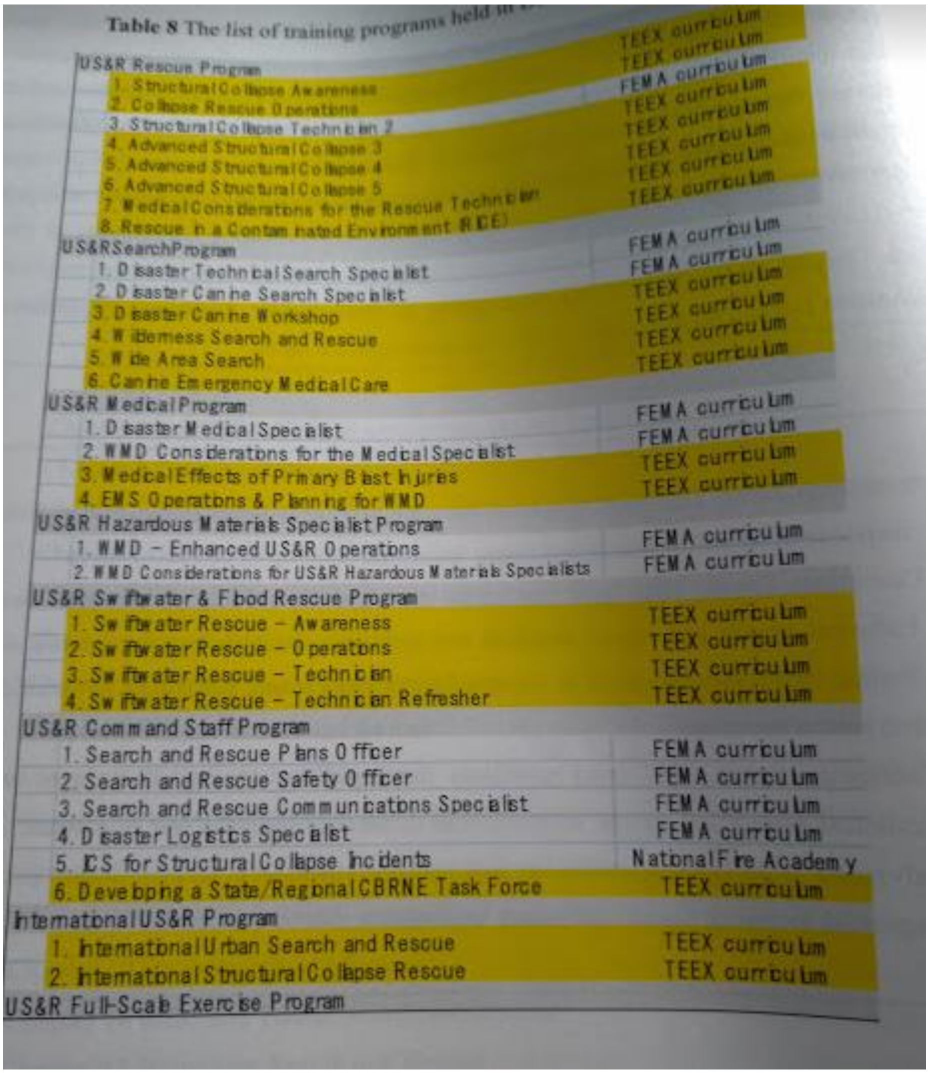

Table 8 The list of training programs held in ...

US&R Rescue Program	
1. Structural Collapse Awareness	TEEX curriculum
2. Collapse Rescue Operations	TEEX curriculum
3. Structural Collapse Technician 2	FEMA curriculum
4. Advanced Structural Collapse 3	TEEX curriculum
5. Advanced Structural Collapse 4	TEEX curriculum
6. Advanced Structural Collapse 5	TEEX curriculum
7. Medical Considerations for the Rescue Technician	TEEX curriculum
8. Rescue in a Contaminated Environment (RICE)	TEEX curriculum
US&R Search Program	
1. Disaster Technical Search Specialist	FEMA curriculum
2. Disaster Canine Search Specialist	FEMA curriculum
3. Disaster Canine Workshop	TEEX curriculum
4. Wilderness Search and Rescue	TEEX curriculum
5. Wide Area Search	TEEX curriculum
6. Canine Emergency Medical Care	TEEX curriculum
US&R Medical Program	
1. Disaster Medical Specialist	FEMA curriculum
2. WMD Considerations for the Medical Specialist	FEMA curriculum
3. Medical Effects of Primary Blast Injuries	TEEX curriculum
4. EMS Operations & Planning for WMD	TEEX curriculum
US&R Hazardous Materials Specialist Program	
1. WMD – Enhanced US&R Operations	FEMA curriculum
2. WMD Considerations for US&R Hazardous Materials Specialists	FEMA curriculum
US&R Swiftwater & Flood Rescue Program	
1. Swiftwater Rescue – Awareness	TEEX curriculum
2. Swiftwater Rescue – Operations	TEEX curriculum
3. Swiftwater Rescue – Technician	TEEX curriculum
4. Swiftwater Rescue – Technician Refresher	TEEX curriculum
US&R Command and Staff Program	
1. Search and Rescue Plans Officer	FEMA curriculum
2. Search and Rescue Safety Officer	FEMA curriculum
3. Search and Rescue Communications Specialist	FEMA curriculum
4. Disaster Logistics Specialist	FEMA curriculum
5. ICS for Structural Collapse Incidents	National Fire Academy
6. Developing a State/Regional CBRNE Task Force	TEEX curriculum
International US&R Program	
1. International Urban Search and Rescue	TEEX curriculum
2. International Structural Collapse Rescue	TEEX curriculum
US&R Full-Scale Exercise Program	

Figure 4-2 example of list of search and rescue training couses in Texas

4.2 National USAR system in UK

4.2.1 New Dimension Program

The purpose of this program is to ensure that Fire and Rescue Authorities are sufficiently trained and equipped to deal safely and effectively with major incidents on a national scale. The responsibility of the Department for Communities and Local Government (CLG) has two strategic aims:

(1) To increase national resilience

(2) To enhance the Fire and Rescue Service response

To meet those aims the program comprises five major operational projects:

(1) Urban Search and Rescue (USAR)

(2) Mass Decontamination

(3) Detection, Identification, monitoring

(4) High Volume Pumping

(5) Command and Control

The USAR Project Team comprises of small number of experienced fire and rescue service officers contracted to work for government for the duration of the project. The USAR Project has developed seven strategic objectives that will ensure that the strategic aims of the New Dimension Program are met, these are:

(1) Develop a management and administrative system

(2) Develop a national infrastructure

(3) Provide training and development for FRS personnel

(4) Develop inter-agency systems of work

(5) Increase the organizational knowledge base of the FRS

(6) Develop and improve the FRS operational capability

(7) Develop safe systems of work

4.2.2 USAR Units and modules

The 20 strategically located USAR Units across England & Wales provide the main mechanism of the USAR operational capability. Each USAR Unit has three vehicles that are based on a MAN 4-wheel drive, three-axle vehicle fitted with a Multi-lift hook-lift loading system.

There are five modules for each of the USAR Units forming part of the USAR capability.

Module 1: provides USAR support in the early stage of an incident

Module 2: contains a selection of heavy rescue equipment that would be required at the scene of a major transport incident.

Module 3: provides heavy rescue support in the developing stages of an incident and contains equipment

Module 4: used to carry a Multi-Purpose Vehicle and can also act as a tipper unit for the movement of debris.

Module 5: used to carry timber and equipment and incorporated a tilt-cover and a load securing mechanism.

Photo 1 Standard ISO containers of Modules 1-3

Photo 2 Multilift hook-lift loading system

Photo 3 Loading motion

Photo 4 Multi-Purpose Vehicle

Figure 4-3 Three vehicles in each USAR Unit

4.2.3 USAR infrastructure

In order to support and maintain the national USAR capability, a number of subsidiary projects have been successfully completed. Principal amongst these was the development of national USAR training at the Fire Service college in Gloucestershire.

Figure 4-4 New Dimension USAR training facilities at the Fire Service College

4.3 Trials towards establishing US&R system in Japan

4.3.1 Japan's disaster response systems and their problems

In Japan, though multidisciplinary US&R response teams are not yet established, each responsible organization and government agency has begun to build a response system with US&R capability. However, there are no official teams that include complete multidisciplinary US&R personnel within the team and can respond to domestic disaster; the only multidisciplinary US&R team of Japan is the Japan Disaster Relief team (JDR), which is an international US&R response team to respond to overseas disasters, and cannot be deployed to domestic disasters. Therefore, one of the problems of Japan is that response from different organizations and agencies must quickly establish ad hoc tight-knot collaborations, which is very difficult, to respond effectively and efficiently against catastrophic disasters such as structural collapse disasters.

Photo 7 Emergency Fire Response Teams **Photo 8** Police Emergency Rescue Units **Photo 9** Disaster Medical Assistance Teams

Figure 4-5 Fire and Disaster Management Agency of Japan (FDMA)

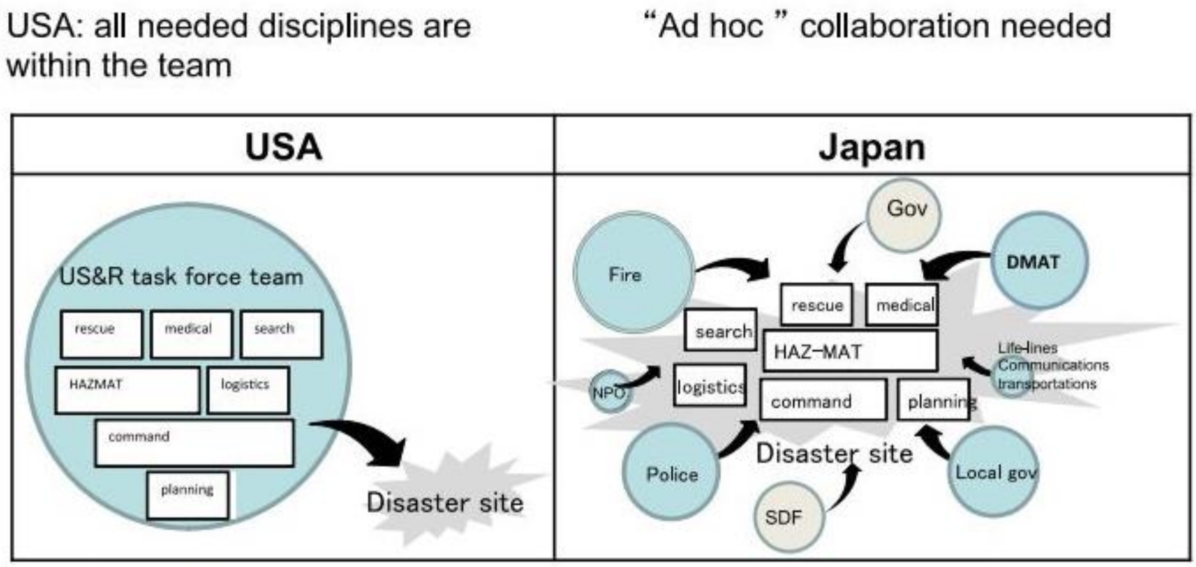

Figure 4-6 Japan's disaster response compared to that of USA with task force teams

4.3.2 Development of responder' US&R capabilities in Japan

Large numbers of people died by crush syndrome in the tragic 1995 Great Hanshin-Awaji Earthquake Disaster (Kobe Earthquake). At that time, not many doctors had detailed knowledge on crush syndrome, but after the earthquake, a leading doctor is self-defense force went through CSM (Confined Space Medicine) training in USA and UK. Those trained doctors saved lives of several crush syndrome patients in the 2005 Amagasaki Train Crash.

These two structure collapse disasters underscored the difficulty and importance of medical support integrated with rescue operations. In order to start medical support while the victims are still trapped, medical providers must enter into the confined space and execute (CSM) in a dark, hazardous, dusty and confined space. This combination of knowledge and skilled differs from that of ordinary pre-hospital cases and underscores the need to train a care of Confined Space Rescue (CSR) specialists.

Hyogo prefecture has experienced the two major structural collapses disaster in Japan: the 1995 Great Hanshin-Awaji Earthquake Disaster (Kobe Earthquake) and the 2005 Amagasaki Train Crash. On the basis of the lessons learned from these two disasters, Hyogo prefecture constructed Japan's first comprehensive US&R training facility.

Figure 4-7 Hyogo US&R training facility

4.4 "the training program" for US&R teams in Thailand

In disaster and hazard events, the most cases that occur in urban area are structural collapse. Therefore, Urban Search and Rescue (US&R) were established for search (location), rescue (extrication), and initial medical stabilization in order to save the lives of victims trapped in structures of buried in debris at sites of catastrophic disasters. In catastrophic events, US&R are operated by confined space medicine (CSM) and confined space rescue (CSR). Confined space medicine are doctor or medics, who enter into confined spaces to treat patients before removing heavy objects lying on them. They conducted with confined space rescue (CSR) teams that can operate in structural collapse disaster. All of these processes should have an effective training before the real disaster occurs.

In my point of view, disaster and hazard accident are special event that needed specialist to cope with. Some countries may have experienced to implement those events, however, others can learn to prevent and reduced damage from those countries. The important thing when disaster occur is time to help, the faster you done, the live you save. Moreover, teamwork is a core to operate the situation. It is necessary to training respondents to operate in simulation accidents. Moreover, we should have the disaster response systems in order to prepare for the unexpected disaster situation. It should have one organization that is center of response system because it is easy to manage the response teams.

For Thailand, we have a lot of agencies that related to the disaster. All agencies will come to the place where the disaster occurs. However, we sometimes have a limitation about area or time in rescue time, so if many agencies come to that area, it will have more disadvantage than advantage. Therefore, we should train the staff from all agencies that who should have more priority in each situation and work step by step. Moreover, we should prepare the equipment that have to use during rescue and train staff for using. We can use some standards about structure collapse rescue such as ACLS or MIMMS to train all staff and develop some standard questionnaire to make staff work easier.

For example, rescue in Luang cave in the northern part of Thailand last month, a lot of agencies came in that area because they want to help the football team who was in that cave and cannot come out due to the water. I know one person that work about water who have a knowledge about water drainage in cave. However, the leader of this rescue didn't allow him for helping in this rescue because a leader didn't trust him and he was only a subordinate of his agency. Therefore, he asked his director to talk with the leader of this rescue, then he could come in that area and start helping football team. This case can show that if we have an effective management and training, we will know who should come in that area or not, and we will help them faster.

Figure 4-8 Luang cave in Thailand

In the past, Thailand might not more consider about important of Urban Search and Rescue. After we faced with disasters, we realize that it was a necessary organization to implement problems. Our king RamaX ordered some agencies to create a rescue course for training staffs from the real events that occurred. I hope for next disaster we can reduce damage and save more live.

4.5 Conclusion & Recommendation

This chapter is talking about some organize establish to manage in disaster preparedness, management and response. Multidisciplinary US&R operations, involving search (location), rescue (extrication), and initial stabilization, are needed to save the lives of victims trapped in structures or buried in debris at sites of catastrophic disasters.

This organize have to prepare all time to save the people for example the people who stuck on building and that building got fire. Therefore, they must have training program all time.

In my opinion, in the past, Thailand might not more consider about important of Urban Search and Rescue. After we faced with disasters, we realize that it was a necessary organization to implement problems. Our king RamaX ordered some agencies to create a rescue course for training staffs from the real events that occurred. I hope for next disaster we can reduce damage and save more live.

Chapter 5

Multi-disciplinary disaster response operations and training designs

A case study: 2005 Amagasaki train crash, Japan

5.1 Outline

After the rush hour morning, on April 25,2005, a speeding Rapid Service seven-car commuter train jumped off the tracks and crashed into an apartment building. The first carriage slid into the basement first floor parking, and the second carriage was twined around the wall of the apartment. As many as 107 people died in what became Japan's worst rail disaster since 1963.

The 2005 Amagasaki crash was the first successful application of CSM to treat patients trapped under collapsed structure in japan. Well-experienced and trained leading doctors entered into the site in confined space, provided CSM, and saved several crush syndrome patients.

Figure 5-1 Amagasaki train crash site

5.2 Materials and method of the case study

1) To do literature surveys from Hyogo prefecture, Amagasaki Fire Department, Japanese Association of Disaster Medicine, and others.

2) Analyzing record of location and time data of all ambulance from Amagasaki Fire Department.

3) Plotting map of people, vehicles, tents and other resources deployed in response to this disaster from aerial photos and videos of the site from helicopter team.

5.3 Official remarks in the report on features of the disaster and its management

5.3.1 The good points of this disaster and its response

- The time of outbreak of disaster: It occurred on a weekday (Monday) at a new shift time at 9.18 am for many responding organizations and agencies.
- Many Responding organizations and agencies, including municipalities, established an Emergency Control Center (ECC) very quickly.
- Many Responding teams hurried to the site and reached it very quickly.
- Neighborhoods and neighboring companies made outstanding efforts to save, rescue and help the injured people from the crushed train at the so-called "Phase 0" of the disaster.

5.3.2 The bad aspects of the disaster and its response

- Many casualties over a limited area.
- The disaster site was split into two by the railroad: the railroad also separated the communications of the two sides.
- On the day of the accident, these was concern that the apartment building might collapse.
- The underground parking of the building was closed because of gasoline leakage. Equipment recuse might produce sparks, so it took much longer to rescue people.

5.3.3 The aspect of disaster site at each scale dimension.

- 1-m-scale: An ultimately difficult site for operations, and the actors in this scale are the specialists.

Figure 5-2 A doctor entering the confined space to provide medical support (left) and patient with only a partial access (right)

- 10-m-scale: The worst conditioned site with hazardous materials (such as gasoline), heat and darkness of confined spaces, and the actors in this scale can be grasped as the response team.

Figure 5-3 Rescue teams working at the site

- 100-m-scale: The site can be as a typical train accident site that split into two sites by the railroad. It took about an hour for the medical teams to know about many casualties on the opposite side and send a team to help. The railroad separated he communications of each side, as well.

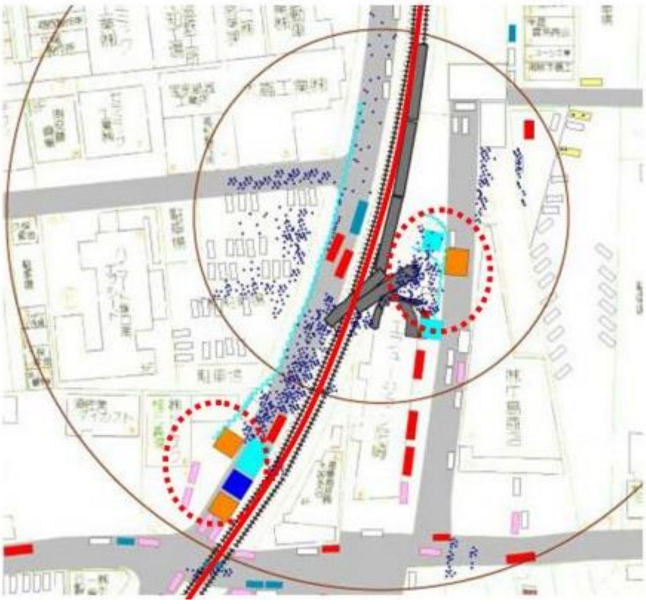

Figure 5-4 Typical train accident site splitting into two sites

- 300 to 500 m. scale: The site includes most of the response operations points (areas) of bronze and silver area of MIMMS: the command post, dispatch points of ambulances and helicopters, and so on.

Figure 5-5 Bronze and silver areas of the disaster site

- 5-km scale: The site can be said to be an area that included the most hospitals to which the patients were transported by motor vehicles (ambulances, buses, patrol cars, vans, trucks and cars).
- 25-km scale: The site which includes the hospitals that accepted patients by helicopters. Although it was not planned in the disaster plan, the emergency heliport was opened on the grounds of a nearby junior high school.

Figure 5-6 The area of the site including patient transports by helicopters

- 50-km scale: Fifty-km-scale-site includes the hospitals that accepted patients by secondary transportation.

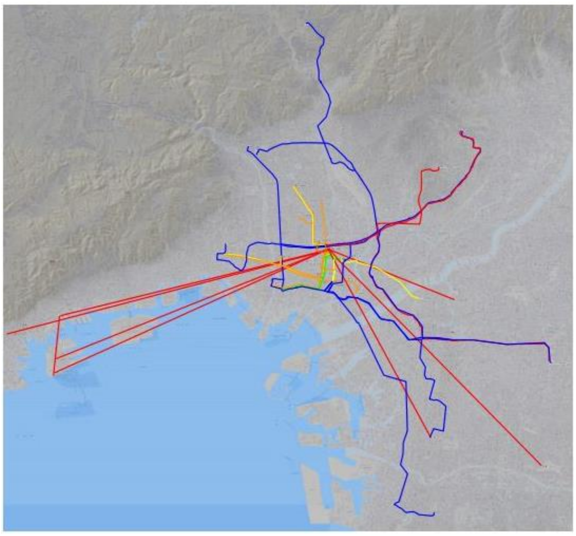

Figure 5-7 The area of the site including secondary transportations of patients

5.4 Training facility designs

5.4.1 Key to success

US&R training facilities are very unique in a sense that they have aims of delivering training that include such activities as breaking, lifting or moving heaving objects, which might change the arrangement of the facility itself. US&R training facilities are essentially different from ordinary facilities and require intense consideration in planning, designing, maintaining and managing them. Without such specialists and engineers, US&R training facilities cannot be built as effective, efficient and safe ones.

5.4.2 Components

- Training Components and areas

  US&R training facilities requires orientation areas, skill-based training areas and scenario-based exercise areas.

- Site Scales

Large-scale facilities have a scale-merit on managing the facility, for US&R facilities need coast and several numbers of engineers and technicians to run the cycles of training: preparing, setting, exchanging and recycling training material and settings.

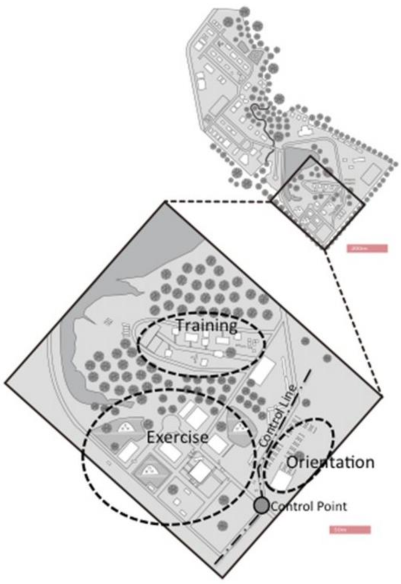

Figure 5-8 Orientation /Training / Exercise area and Control Line/Point in Disaster City (TX)

- Facility designs for skill-based trainings

Necessary skills for each discipline/position can be grasped by training curriculums, position descriptions and codes/guidelines.

- Facility designs for scenario-based/full-field exercises

In FEMA medical specialist training course, three kinds of scenarios are prepared: the tunnel, the windy room, and 48 hours.

Figure 5-9 Panorama view of Disaster City (left) and Passenger Train site (right)

- Planning and design of Hyogo facility

In 2006, Hyogo Prefecture decided to build a US&R training facility to make full of the lessons learnt from the two structural collapse disasters. They then worked on breaking this concept down to a layout, design and details. A concrete design of desirable facility is made and proposed in a model.

Figure 5-10 US&R training facility HYOGO in 1//80th scale model

5.5 Further Researches on US&R

5.5.1 An ergonomic study

For rescue workers, conducting rescue operations in confined spaces poses a great challenge. Severities of environment conditions of confined sites under collapsed structures make CSR (Confined Space Rescue) operations difficult and dangerous. Training rescuers in different height-considered settings can help them better cope with such challenges.

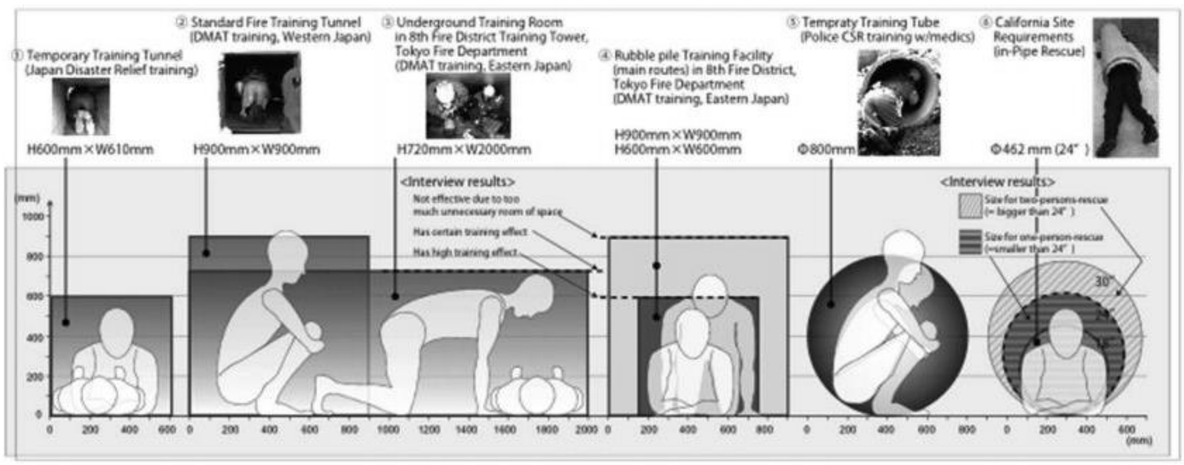

Figure 5-11 Size of existing CSR training structures at Japan and California and evaluations of their training effectiveness by rescue leaders

5.5.2 A sound simulation

In collaboration in rescue teams, they applied an acoustic simulation during a full field exercise in a US&R training session in order to provide a noisy environment simulating that of an actual operation site.

5.6 Conclusion & Recommendation

This chapter is talking about the case study. It was 2005 Amagasaki train crash in Japan. That incident was caused to made 107 died in what became Japan's worst rail disaster since 1963. The 2005 Amagasaki crash was the first successful application of CSM to treat patients trapped under collapsed structure in japan. Well-experienced and trained leading doctors entered into the site in confined space, provided CSM, and saved several crush syndrome patients. This case study taught us how to divide the severe of damage and the people who have injury that we should help first. Depend on situation.

Based on empirical data from the 2016 Kumamoto earthquakes, rescue training unit designs and training programs were examined in terms of the PDCA cycle. Original assumptions made for training purposes were found to be valid and effective, while some recue methods such as making a space beneath obstacles were found to be absent in the pre-earthquake trainings. From these findings, training improvements were made to ensure more effective and efficient training.

In my opinion, this knowledge is useful. Since we can know the situation that we should prepare somethings to help the victims for example equipment to help people who stuck in the car accident.

Chapter 6
Site Visit (Amagase Dam)

The Amagase Dam (figure 1) is located on the Uji River, Kyoto, Japan. It is constructed by concrete in arch shape. They design this arch shape dam because the mountain beside the river is strong enough for receive the hydrostatic force from the water in the reservoir. Upstream of the dam is Lake Biwa and downstream of the dam is Yodo-gawa River which flows into Osaka Bay. This dam is very important because it is only one dam that is located on the Uji River. Therefore, this dam need an effective management for having a good reservoir operation.

Figure 6-1 Amagase Dam

This dam is a multipurpose dam consist of flood control, hydroelectricity power station and water supply. This dam can generate electricity even in the summer about 110 MW. However, the main purpose of this dam is flood control. Although the discharge capacity of the dam is 900 m3/s, it is not enough for flood control. As area around Lake Biwa and the Uji river often damage from flooding. Therefore, the Amagase dam redevelopment project was created for solving this problem. Therefore, the objectives of this project are improvement of flood management and water utilization by increasing the discharge capacity.

Construction on the dam began in 1955 and it was complete in 1964. The pumped-storage power station became operational in 1970. Both plants are owned by Kansai Electric Power Company. In this project, the tunnel-type discharge facility is the way to increase discharge capacity. Therefore, they design to construction the tailrace tunnel in order to increase discharge capacity. The tailrace tunnel has dimension 26 x 23 m. and has maximum discharge 600 m3/s. Therefore, when they finished the construction, the discharge will be increased from 900 m^3/s to 1500 m^3/s. After construction, flooding problem at upstream and downstream will be decrease and power generation will be increase. For construction the intake, Taisei company is corporate by using machine. They construct intake at 300 m. below water surface.

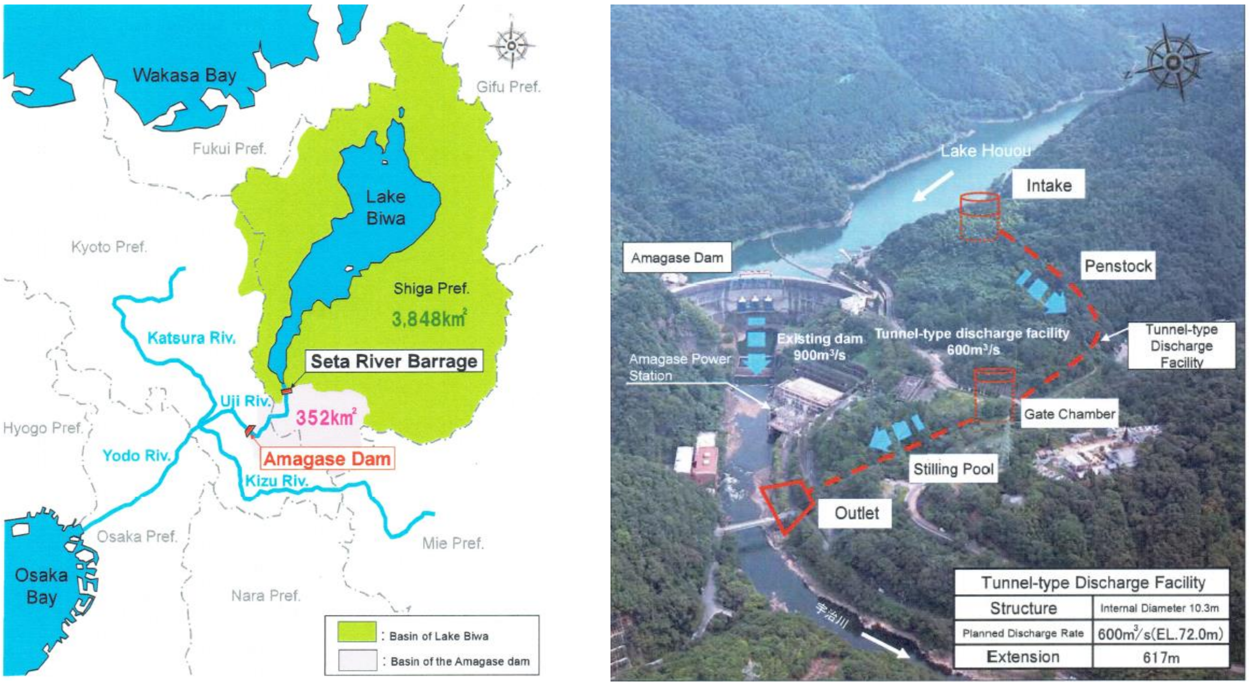

Figure 6-2 Illustration of the Amagase Dam basin

6.1 Development of the Amagase Dam Redevelopment Project

Table 6-1 Development of the Amagase Dam Redevelopment Project

Year	Activity
1953	The dam received massive damage by Typhoon No.13
1954	The Basic Plan to Repair the Yodo-gawa River System was finalized
1964	The Amagase Dam was completed
1965	The dam received tremendous damage by flood caused by typhoons including Typhoon No.24
1969	Kyoto Prefectural Water works requested the increase of 0.6 m^3/s
1971	The Yodo-gawa River System Construction Implementation Basic Plan was revised
1972	The Kansai Electric Power Co., Inc. requested the increase during the summer
1975	Preliminary research was started
1989	Construction was started
1995	The Basic Plan was formulated (Notification No.996 of the Ministry of Construction
1997	The River Act was revised
1998	Construction of road used for construction was started
2007	The Basic Policy for River Improvement of the Yodo-gawa River System was established
2009	The River Improvement Plan of Yodo-gawa River System was formulated
2013	Tunnel Construction was started
2018	The Amagase Dam Redevelopment Project will be completed

6.2 Background (damage from past floods)

In the past, areas around Lake Biwa and the Uji River have often suffered damage from flooding.

1) Typhoon No.13 (September 1953)

- Fatalities (including missing persons) 178
- Casualties 194
- Complete collapse and washed away/ half collapse 676 houses
- Flooded above/ below the floor 56, 194 houses

2) Frontal line and Typhoon No.7 (August 1959)

- Fatalities (including missing persons) 23
- Casualties 29; complete collapse and washed away 152 houses
- Half collapse and washed away 115 houses
- Flooded above the floor 7,949 houses; flooded below the floor 44, 103 houses.

3) Typhoon No.15 (Typhoon Isewan)

- Fatalities (including missing persons) 47
- Casualties 53
- Complete collapse and washed away 586 houses
- Half collapse and washed away 1,312 houses
- Flooded above the floor 9,927 houses
- Flooded below the floor 27,632 houses

4) Frontal line and Typhoon No.26 (October 1961)

- Fatalities (including missing persons) 2
- Casualties 4
- Complete collapse and washed away 5 houses
- Flooded above the floor 520 houses
- Flooded below the floor 2,209 houses

5) Typhoon No.24 (September 1965)

- Fatalities (including missing Persons) 4
- Casualties 106
- Complete collapse and washed away 248 houses
- Half collapse and washed away 4,540 houses
- Flood above the floor 12,238 houses
- Flooded below the floor 58,501 houses

6) Typhoon No.10 (August 1982)

- Fatalities (including missing persons) 10
- Casualties 12

- Complete collapse and washed away 24 houses
- Half collapse and washed away 34 houses
- Flooded above the floor 5,573 houses
- Flooded below the floor 5,084 houses

7) A seasonal rain front (May 1995)

- Flooded below the floor 39 houses
- Buried and washed out cultivated fields 281.9 ha

8) Typhoon No.18 (September 2013)

- Fatalities (including missing persons) 4
- Casualties 12
- Complete collapse and washed away 10 houses
- Half collapse and washed away partially damaged 502 houses
- Flooded above the floor 2,211 houses
- Flooded below the floor 4,684 houses

6.3 Project Objective

6.3.1 Water Control (improvement in the function of flood control)

The flood control function of the Amagase Dam will be improved by more effective use of the water control volume of the dam and an increase in the discharge capacity. The discharge capacity will be increased to 1,500 m^3/s from 900 m^3/s

The Amagase Dam Redevelopment project will promote more effective utilization of the reservoir, which will improve the volume of water to be used not only for flood management but also for water utilization

6.3.2 Water Utilization (enhance power generation capacity)

After the Amagase Dam Redevelopment Project, more water will be sent to the Kisenyama Dam during the summer, the most flood-prone season. This enables the Kisenyama Power Station to stably generate electricity even in the summer (the season of high demand for electricity) and newly supply approximately 110 MW (110,000 kW) of electricity.

More water for the water supply can be taken by improving the efficiency of reservoir utilization through the Amagase Dam Redevelopment Project 51,840 of water (approx. 170,000 persons) can be newly supplied stably.

6.4 Composition and Roles of the Facility

The tunnel-type discharge facility of the Amagase Dam comprises of the following five facilities:

6.4.1 Intake

The intake of the tunnel-type discharge facility. A “repair gate” is installed to block the stream during an emergency or repair.

6.4.2 Penstock

The tunnel to lead the stream to the lower reaches. Large circular tunnel with an inside diameter of 10.3 m.

6.4.3 Gate chamber

The gate chamber is a facility with a gate adjust the outlet rate. Two “main gates” and two “sub gates” are installed.

6.4.4 Stilling Pool

The stilling pool is as facility that reduces the power of the effluent. Considering the surrounding environment, this facility is located inside the tunnel.

6.4.5 Outlet

The outlet of the tunnel-type discharge facility.

6.5 Technical Point

1) One of the Largest tunnels in Japan

The tunnel-type discharge facility of the Amagase Dam is the largest aqueduct tunnel in Japan with a total length of 617 m, and a maximum tunnel diameter of 23 m in width and 26 m in height. Safety against large-scale earthquake has also been considered.

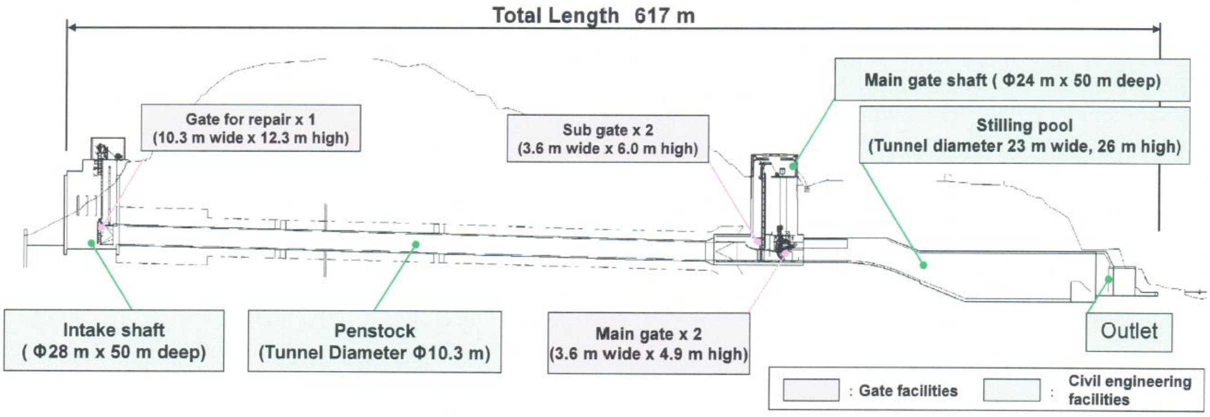

Figure 6-3 Schematic of tunnel

This kind of structure has never been designed in Thailand. Normally, many reservoirs in Thailand don't have a lot of water as Biwa lake flow into the reservoirs, so in flooding time, spillway is enough for drain the water from the reservoirs. However, from the climate change which can create the increasing of rainfall intensity, so this case study may give a lot of advantage in Thailand in the future.

2) Adoption of the in-tunnel energy dissipation method

Out of consideration to the environment surrounding downstream rivers (noise and a flow of water), facility (23 m wide, 26 m high) is installed inside the tunnel to dissipate the flow of water. The effects to dissipate a flow of water were confirmed in the hydraulic model experiment.

6.6 Consideration to the Surrounding Scenery

There are power station buildings acclimated to the surrounding scenery in the downstream area of the dam, and Lake Ho-o in the upstream area. The area is also used as the walkway from Uji city area to the Amagase Dam. (Figure 6.4)

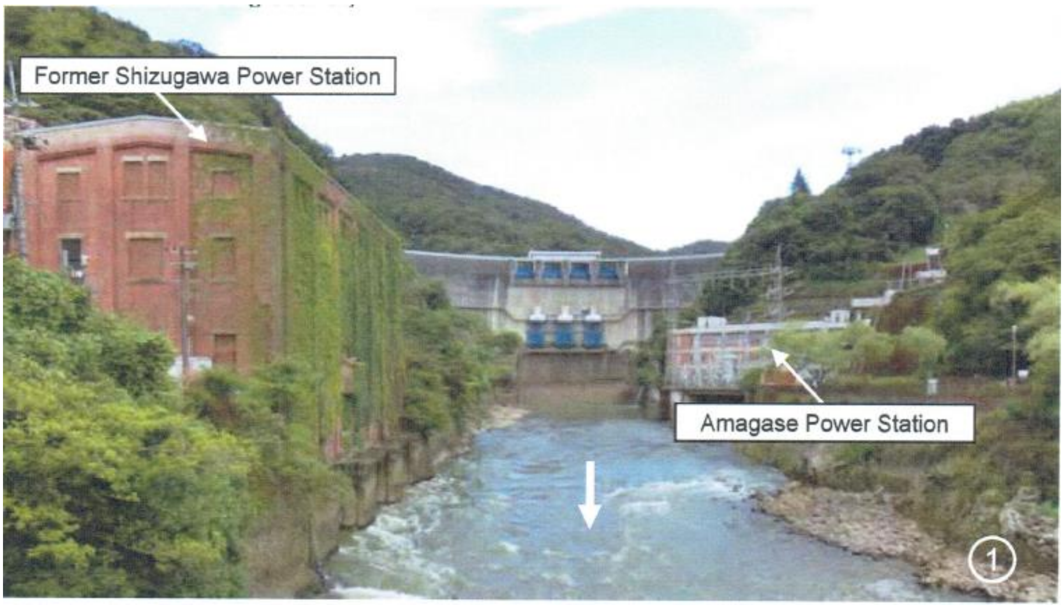

Figure 6-4 Former Shizugawa Power Station, Amagase Power Station: Decoration acclimated to the surrounding scenery

Various efforts are taken to make scenery-conscious facilities by asking for opinions of scholars and experts through the "Scenic Review Committee for the Amagase Redevelopment Project"

- Concept for the intake: The design appropriate for the independent building on the lakeside with the background of water surface and the sky.
- Concept for the gate chamber: The design standing in the shadow of the green of Satoyama.
- Concept for the outlet: The design acclimates to bare rock, revetment, and roads, that is unified as an outlet structure.

6.7 Dam Redevelopment in Japan

Responses to the new demand for water control and water use with consideration to the environment and economy are required. Along with the technological development of design and construction work, the "dam redevelopment" that uses existing dams effectively is underway.

6.8 Conclusion & Recommendation

This chapter provided a brief description of the important of Amagase Dam. The Amagase Dam is located on the Uji River, Kyoto, Japan. It is constructed by concrete in arch shape. They design this arch shape dam because the mountain beside the river is strong enough for receive the hydrostatic force from the water in the reservoir. Upstream of the dam is Lake Biwa and downstream of the dam is Yodo-gawa River which flows into Osaka Bay. This dam is very important because it is only one dam that is located on the Uji River. Therefore, this dam need an effective management for having a good reservoir operation.

This dam is a multipurpose dam consist of flood control, hydroelectricity power station and water supply. This dam can generate electricity even in the summer about 110 MW. However, the main purpose of this dam is flood control. Although the discharge capacity of the dam is 900 m3/s, it is not enough for flood control. As area around Lake Biwa and the Uji river often damage from flooding. Therefore, the Amagase dam redevelopment project was created for solving this problem. Therefore, the objectives of this project are improvement of flood management and water utilization by increasing the discharge capacity.

In this project, the tunnel-type discharge facility is the way to increase discharge capacity. Therefore, they design to construction the tailrace tunnel in order to increase discharge capacity. The tailrace tunnel has dimension 26 x 23 m. and has maximum discharge 600 m3/s. Therefore, when they finished the construction, the discharge will be increased from 900 m3/s to 1500 m3/s. After construction, flooding problem at upstream and downstream will be decrease and power generation will be increase. For construction the intake, Taisei company is corporate by using machine. They construct intake at 300 m. below water surface.

This kind of structure has never been designed in Thailand. Normally, many reservoirs in Thailand don’t have a lot of water as Biwa lake flow into the reservoirs, so in flooding time, spillway is enough for drain the water from the reservoirs. However, from the climate change which can create the increasing of rainfall intensity, so this case study may give a lot of advantage in Thailand in the future. In term of water supply, we can use this kind of tunnel to bypass the water from some rivers to the reservoirs. For example, the tunnel project in Northeast part of Thailand which bypass the water from Mekong river to the Loei river and bring it to the reservoir.

Chapter 7
Advancement on humanitarian logistics

Humanitarian logistics is viewed simply as process of activities aimed at saving lives and eliminating the sufferings of victims in a disaster or catastrophe. The importance of humanitarian logistics has been driven mainly from statistical data of rising trend of natural disasters reported between 1975 and 2011 as shown in Figure 7.1 and increased intensity of the disasters that caused huge damage as shown in Figure 7.2, especially in the recent Tohoku Earthquake event that happen on 11th March 2011. The frequencies of disasters occurring in the Asia continent observed in Figure 7.3 add on to the significance of understanding humanitarian logistics in this region and to build a responsive human resource team in such catastrophic scenario.

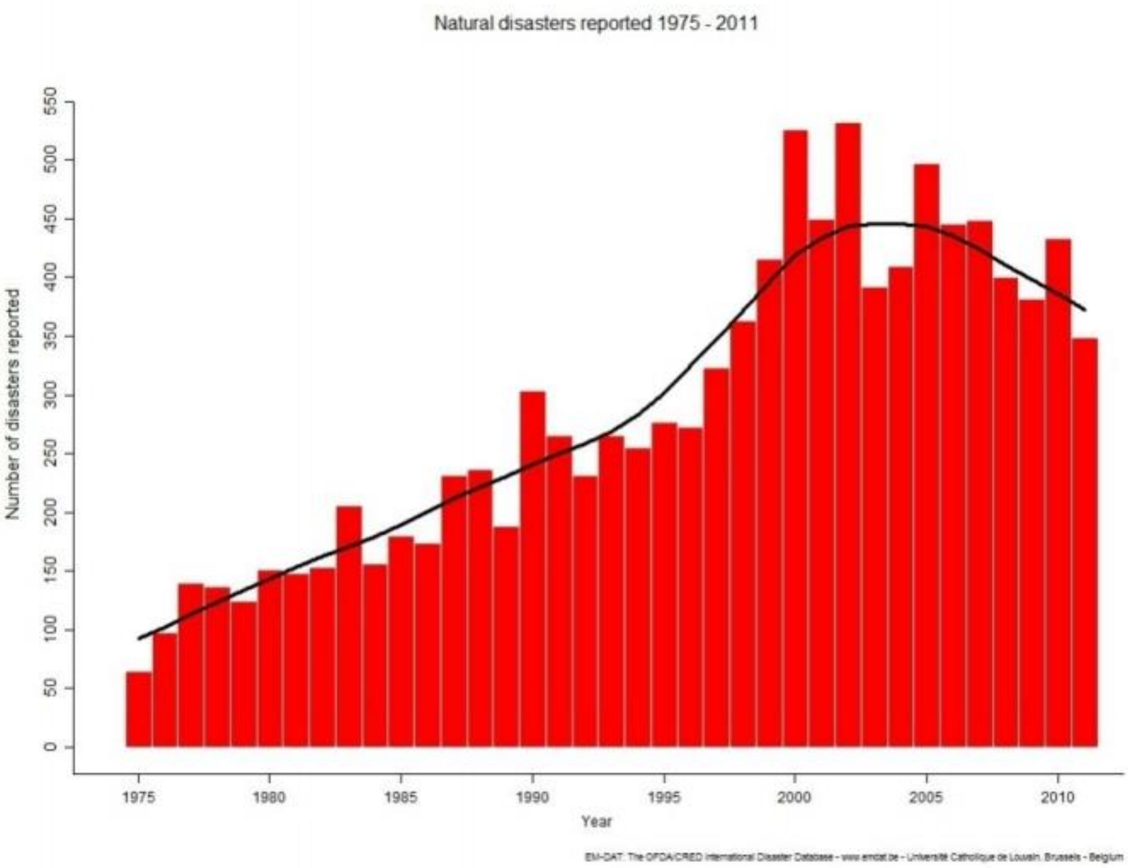

Figure 7-1 Natural disasters reported between 1975 and 2011 (Source: EM-DAT)

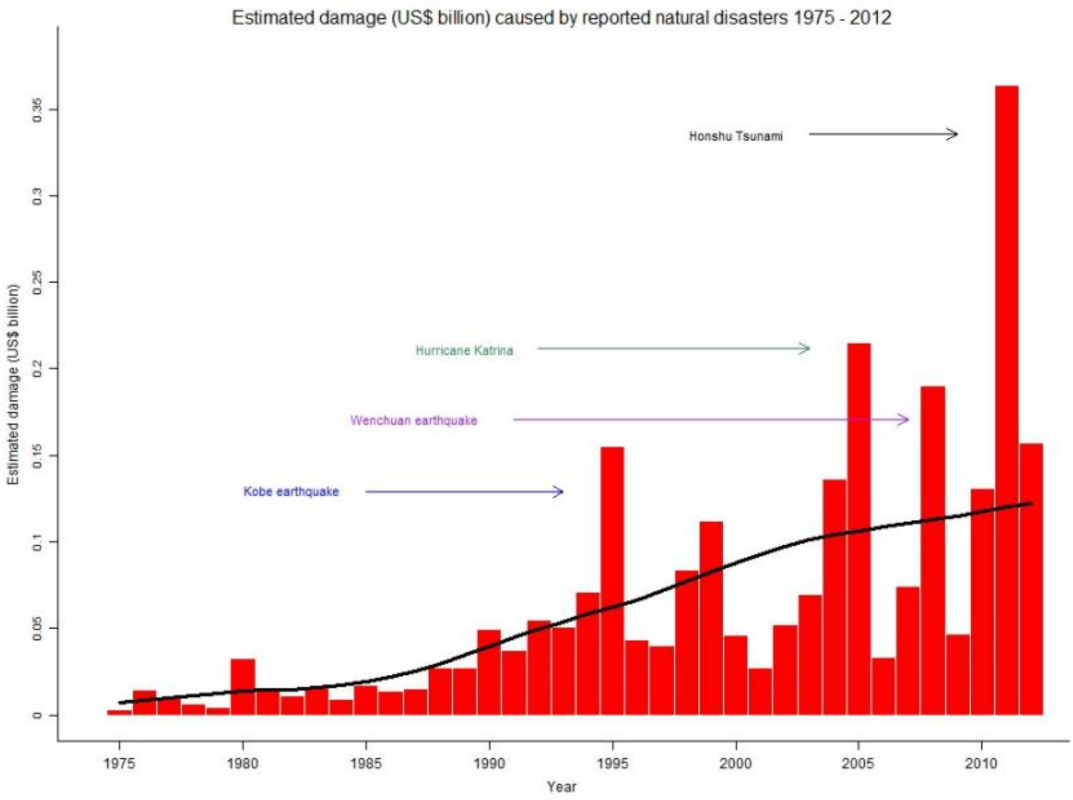

Figure 7-2 Estimated damage by natural disasters between 1975 and 2012 (Source: EM-DAT)

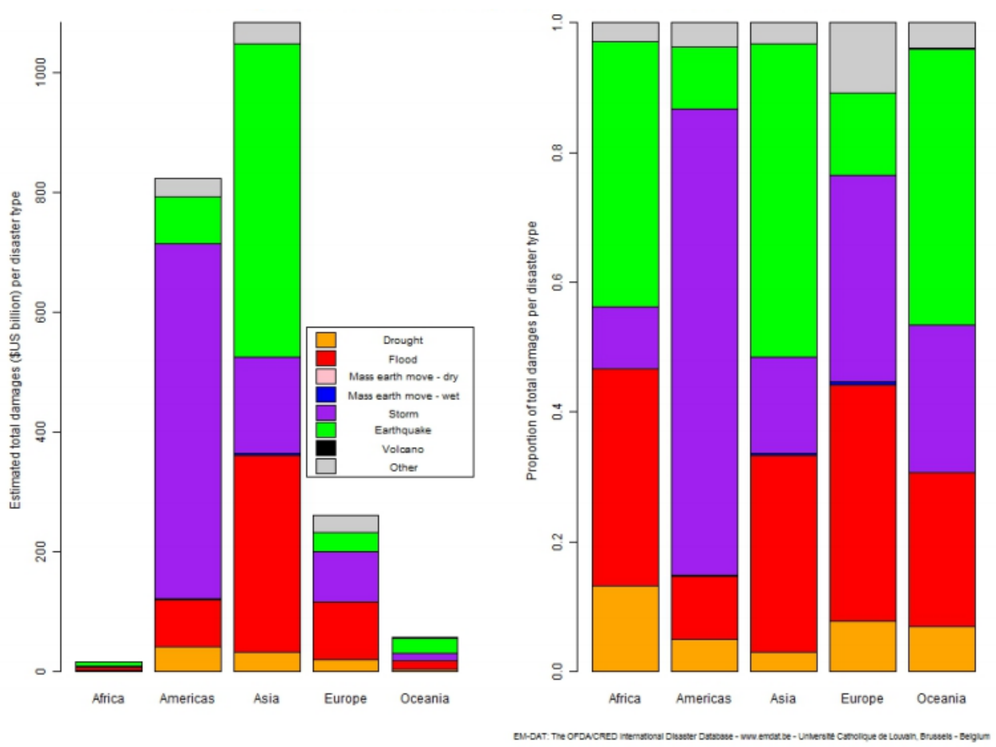

Figure 7-3 Total damages caused by reported natural disaster – 1990 to 2012 (Source: EM-DAT)

7.1 Difference between Business logistics and Humanitarian logistics

The definition of "humanitarian logistics" has been known commonly as the "process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people". Such definition usually covers several activities, which includes preparation, planning, procurement, transportation, warehousing, tracking and customs clearance (Thomas, 2005). Another related term is the "emergency logistics", which is known as "a process of planning, managing and controlling the efficient flows of relief, information, and services from the points of origin to the points of destination to meet the urgent needs of the affected people under emergency conditions" (Sheu, 2007). A more specific aim related to disaster relief operations is to "design the transportation of first aid material, food, equipment, and rescue personnel from supply points to a large number of destination nodes geographically scattered over the disaster region and the evacuation and transfer of people affected by the disaster to the health care centers safely and very rapidly" (Barbarosolu et al., 2002).

In contrast, the definition of business logistics is usually defined as "the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption for the purpose of conforming to customers, requirements at the lowest total cost".

Both definitions of humanitarian logistics and business logistics seem similar, but the distinct differences of each process lie on the environment that it is performed on, the objectives they pursue, characteristics of demand information and supporting system.

Firstly, the objective of business logistics usually deals with the minimization of overall private costs or cost of item movement and storage. Such costs typically include the facility cost, overhead cost, transaction cost, inventory cost, delivery cost, handling cot and operating cost. Another goal of business logistics considers the value delivered to customers in term of service improvement, which could lead to revenue increase; therefore, more attention is focused on final customers as the source of income for the entire supply chain. However, the objective of humanitarian logistics deals with minimization of overall social costs like human sufferings and loss of lives. Such strategic goals are more difficult to achieve under financial budget or worst constraints than business logistics. The customers of business logistics include the organizations and individuals and they have the freedom to analyze the market and select the products to acquire based on the quality, price, availability and service. The stakes for failed delivery to customers are usually lost commerce, costs increment and dissatisfaction from customers. On the other hand, the customers in humanitarian logistics often refer to the aid recipients and are seldom involved in commercial transaction. However, since the relief supplied also comes in the form of in-kind donations, donors may be considered by humanitarian organizations as customers and provide services for donors to manage their contributions. In addition, customer services or marketing of humanitarian services may need to target supplies and donors. The aid recipients may not have the freedom in business logistics to demand their choice of supplies and they do not have any formal contract of agreement with the suppliers on the agreed service and quality standards. The consequences of failed delivery in humanitarian logistics are sadly either prolonged sufferings or even deaths.

Secondly, the management of resource in business logistics is usually easier than humanitarian logistics as the resources are usually known and readily controllable for logistics suppliers. Resources in humanitarian logistics from private or public sectors are usually uncertain and the communication breakdown among relief suppliers, logistics providers and victims during disaster worsen the problem of resource management (Sheu, 2007). In some cases, the publicity demand for food and medicine may be required prior to the basic machinery requirement like forklifts.

The demand information in business logistics usually follows predictable patterns as the orders of products are provided by customers actively and directly; on the other hand, demand information from victims in humanitarian logistics are usually limited and unidentifiable, especially in the immediate impact from disasters. In addition, the demand information from business logistics is usually aggregated while it is typically disaggregated for humanitarian logistics. The required humanitarian supplies and emergency services vary depending on the impact of disaster, he demographics, social and economic condition of affected areas. The demand in business logistics, the demand is estimated based in disaster assessment and often required immediate attention and delivery. In term of price, the rate for business logistics are relatively static over the reasonable timeline but the increase in demand affected by disaster leads to price increase by suppliers. The demands of humanitarian aid are usually generated with no specific option and often under inevitable circumstances. The demand is assessed through the aid agencies and supplies may be delivered in limited quantities due to supply constraints. In certain cases, supplies to victims may be endangered due to rebels blocking off the excess for aid supply and looting may occur.

The supporting system in business logistics like the network communication, road infrastructure and facilities is usually stable and functioning properly. The reliability of transport systems is usually favorable and provides well established distribution channels and almost static flows. The transport capacity is sufficient to meet customer demands using all available modes of transport; however, the supporting system in humanitarian logistics may be stable at times but may not always be functional. In major catastrophic events, the consequences include a destabilized infrastructure with a lack of electricity and limited transport infrastructure and road network. The uncertainty of demand location makes it more difficult for humanitarian logistics to establish reliable transport routes for delivering goods to the victims.

The general process of business logistics starts from demand management to supply management and finally fulfillment management, where a manager ensures that the demanded goods reached the customers in correct order and on time. The managers will often try to resolve complaints from customers and a good fulfillment manager has exceptional skills in overseeing the ordering and delivery processes. The structure of humanitarian logistics involves several actors that may not be linked to the benefits of satisfying the demands of victims. The multiple actors may not have any business relationships in the past and may not be linked to each other, but all the actors involved in the humanitarian aid operations are brought together and linked in some ways. The actors may include donors, aid agencies, non-governmental organizations (NGOs), government, military and logistics providers.

Table 7-1 Difference between business logistics and humanitarian logistics

Topic	Business Logistics	Humanitarian Logistics
1. Demand	Stable Predictable	Dynamic Unpredictable
2. Network	Well connected Reliable	Disrupt Unreliable
3. Resources	Reliable Expandable	Limited
4. Supplies	Well controlled Matching demands	Intermittent Insufficient
5. Decision making	Streamlined Calm	Chaotic
6. Objective	Cost minimization Profit maximization Customer's satisfaction	Coverage maximization Delay minimization Equity Cost effective

The performance measurements for humanitarian logistics are viewed as important as they provided relief organizations with feedbacks of their decisions and are crucial for future service improvements and accountability. The measurements can also help to manage resources effectively and estimate demands for larger crisis. The proposed performance measurement framework suggested by Beamon and Balcik (2008) is summarized in Table 7.2. The framework consists of three parts and they are resource performance metric, where the cost is predominant; output performance metrics, which consider the characteristics of supply; flexibility performance metric, which includes the range flexibility and response flexibility. Range flexibility refers to the extent of possible changes to the operation and the response flexibility refers to the simplicity in terms of cost and/or time for operation changes.

Table 7-2 Performance measurement framework for relief chain

Resource	Output	Flexibility
Dominating cost – Cost of supplies – Cost of distribution – Cost of inventory	Response time Number of items supplied Supply availability	Range flexibility Response flexibility

7.2 Factors to consider for transport strategy

A simple definition for transportation or last-mile delivery in the context of humanitarian logistics is "the activities involved in moving supplies from point of origin to internal customers or beneficiaries" (LOG, 2012). A cluster approach Logistics Cluster was setup and endorsed by Inter Agency Standing Committee (IASC) in September 2005 to gather over 28 humanitarian organizations, academia and the private sector to produce a set of guidelines when implementing humanitarian logistics. In the subject of transport strategy specified in the guide, factors that were considered for developing a transport strategy are follows:

1) Ways of identifying transport service providers

2) Ways to manage the transport; for example, should the transport fleet be outsource or lease

3) What is the available capacity of transport modes and their costs

4) What are the quantities required to be moved over the timeframe

5) What are the characteristics of goods and supplies to be transported

6) What is the coverage of delivery in term of distance

7) What are the environmental issues relating to climate, taxes etc.

8) What are the origin and destination

9) What are the quantities of distribution centers, warehouses and other destinations

10) What are the available human resources

11) What is the condition of terrain and the type of disasters experienced

12) What is the security condition of the impacted area

13) What is the available funding

A typical relief chain involving international actors is shown in Figure 7.4. The international supplies will arrive at the port of entry and distributed to local central warehouses and other distribution points. The last-mile distribution involves several distribution routes ministered by delivery vehicles to the beneficiaries.

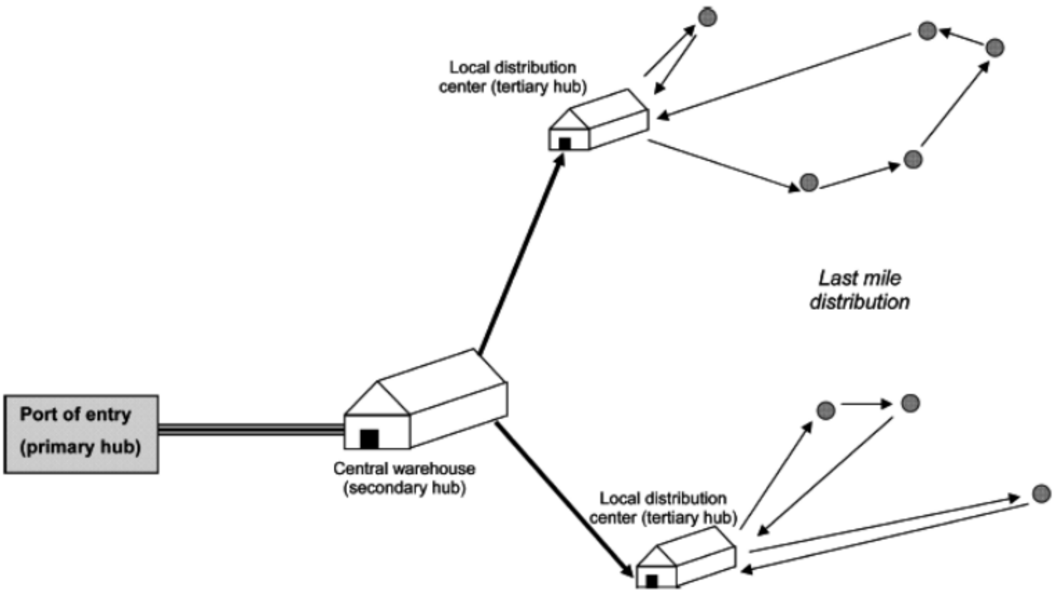

Figure 7-4 Typical relief chain involving international actors (Source: Balcik et al., 2008)

7.3 Routing and scheduling

The aim for effective routing and scheduling for humanitarian logistics is required to meet the objectives of the following:

1) Maximize vehicle utilization where the vehicle has maximized the number of load journeys
2) Minimize the distance travelled and minimize the non-moving time
3) Meet the requirements of customer in term of cost, service time, and other legal terms like vehicle capacity and maximum driving hours for drivers

A satisfactory scheduling is one that minimizes either the total distance or time travelled by the vehicles. In the process of observing and selection from all possible routes, some operational conditions should also be applied:

1) There is a limited number of times each delivery point can be visited in a day
2) The vehicle travel and driver’s driving time is limited in a day

3) The capacity of the delivering vehicle is fixed

4) The volume of goods at each receiving point is assumed to be known and is less than the truck

capacity.

5) The drop-off point that is known in advance has information of travel time between origin and

destination

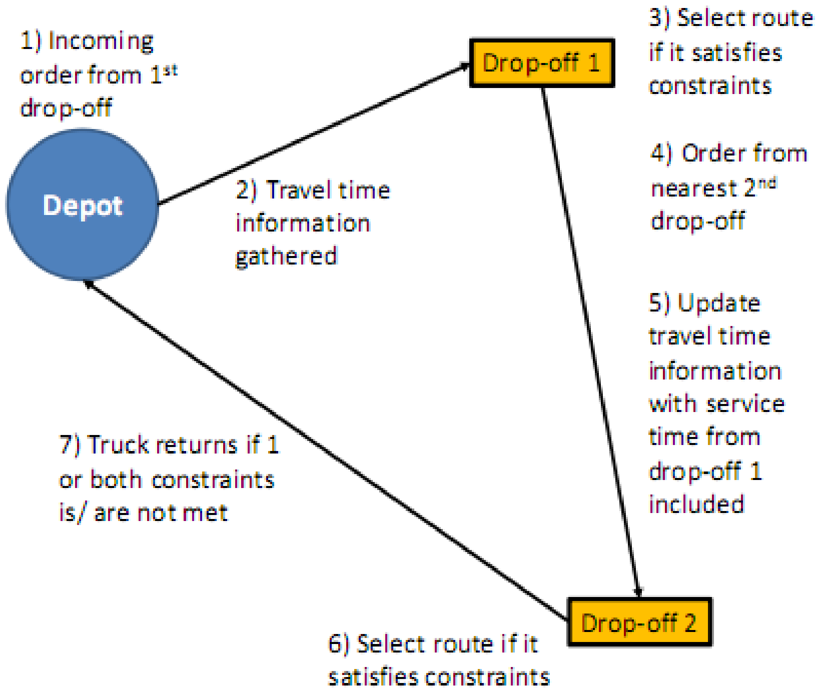

Figure 7-5 Operational routing and scheduling process

7.4 Humanitarian logistics considering resilience of the affected population

Lack of available resources, infrastructure, and even incomplete information in immediate post-disaster situation, usually results in a relief distribution that is either less than the required amount or arrives after a long wait. If the supply of the relief goods is less than what is demanded or if it arrives with a delay, it will cause a decrease in the resilience of the affected population with time. Therefore, new relief distribution models can be established, which are capable of providing a multi-period relief distribution plan considering the deprivation cost (to model decrease in resilience) if the demands are not met completely. The main difficultly in a multi-period (day) relief distribution plan could be the unjust treatment of the relief demand locations, for which less than demand relief is distributed on day 1. To overcome this sensitive issue of equity and to model the decreasing resilience of people staying at such locations, the deprivation cost in the subsequent periods (following days) can be linked to the amount of shortage in supply in the period (day). As shown in Figure 7.6, the changes in the resilience can be modeled by assigning variable penalties to the shortage of relief supply, i.e. the resilience penalty coefficient (p_i^t) in period *t* is dependent on the demand to supply ratio of the previous period.

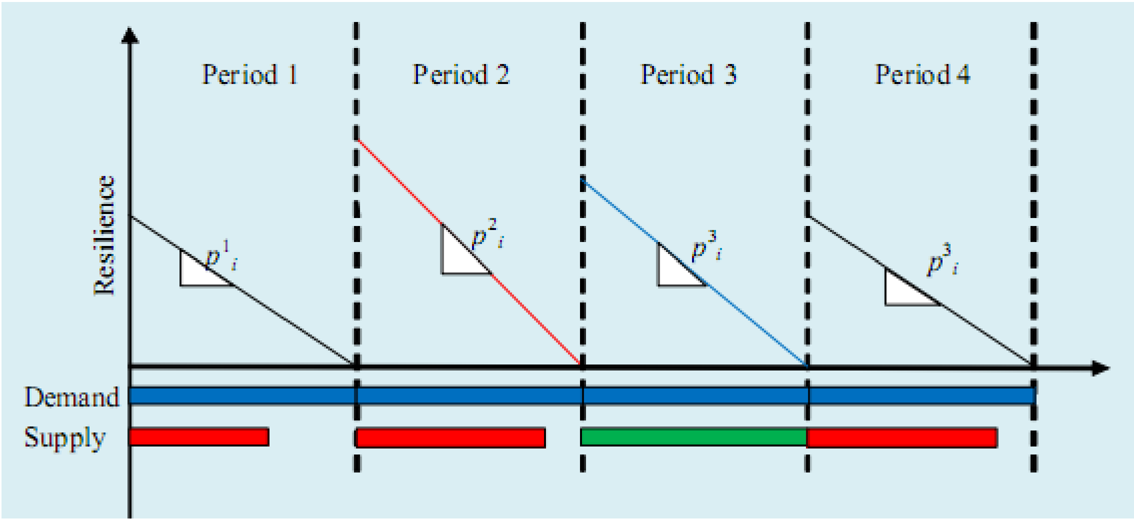

Figure 7-6 Dynamic resilience based on demand and supply of relief goods

7.5 Conclusion & Recommendation

This chapter has given an overview of the subject on humanitarian logistics, which started with the comparison of business logistics and humanitarian logistics. The differences in their objectives, characteristics of demand information and supporting system were described. Further elaboration on the topic of humanitarian logistics was given in terms of its typical flow in providing relief aids, the actors involved in the relief chain, the important of coordination and the suggested performance measurements. The aim of humanitarian logistics is best described by the principles of Humanitarian and Emergency Logistics Professionals (HELP) Forum in United Kingdom as having the “Right people, equipment and material, in the right place, in the right sequence as soon as possible, to deliver the maximum relief at the least cost, reduced suffering and the best use of donated funds”.

Next is a brief description of the importance of last-mile delivery in relief operations as it served as one of the critical point to alleviate sufferings and save lives. Existing concepts of routing and scheduling are described followed by the introduction of advance relief routing models that should solve the problems faced by the relief organizations. In order to model a useful routing and scheduling model for relief distribution, it is important to learn key lessons from the past experience and to understand the problems faced by the relief organizations. It may be possible to use simple routing models for independent drivers for providing distribution work and reserve more advanced relief routing models for large organizations with technological and collaboration capabilities.

Actually, the humanitarian logistics will use during the disaster that caused several problems related to infrastructure, communication and coordination problems. Such problems hampered the distribution of relief goods, especially during the last mile distribution. Therefore, the field survey also suggested that one should not underestimate the humanitarian logistics challenge in disasters. Integration of the private sector with the government organization before the disaster to work together for humanitarian logistics effort was also a recommendation. The humanitarian logistics should be formalized between the Government, social and religious groups to establish a collaborative network operation for global connectivity and last-mile delivery.

Chapter 8

Toward a Resilient Society Against a Mega-Tsunami Disaster

8.1 Mega Disasters

8.1.1 Past Mega Disasters

The meaning of "Mega Disasters" is enormous events in which 1,000 or more people died or went missing at once. There have been 22 mega disasters in Japan and 8 mega disaster in U.S. since 1900 (Table 8.1).

Table 8-1 Mega Disaster in Japan and the United States since 1900

year	Japan		The U.S.	
	Disaster	Number of Deaths and Missing Persons	Disaster	Number of Deaths and Misssing Persons
1900			Galveston Hurricane	6000-12000
1960	Typhoon	approx. 1500	San Francisco Eqrthquake	98-3000
1910	Typhoon	approx. 1400		
1917	Typhoon	over 1300		
1918			Cloquet, MN&WI Forest Fire	1000
1923	Great Kanto Earthquake (Tsunami)	Approx. 105000		
1927	Kita Tango Earthquake	2925		
1928			SE FL/Great Okeechobee Hurricane and Flood	1836-3000
1933	Showa Sanriku Earthquake (Tsunami)	3064		
1934	Typoon Muroto	3036		
1936			Illinois Heat Wave	2696
1942	Typhoon	1158		
1943	Tottori Earthquake	1083		
1944	Tonankai Earthquake (Tsunami)	1251		
1945	Typhoon Makurazaki	3756		
	Mikawa Earthquake	1961		
1946	Nankai Earthquake (Tsunami)	1330		
1947	Typhoon Kathleen	1930		
1948	Fukui Earthquake	3769		
1953	West Japan Torrential Rains	1013		
	Nanki Torrential Rains	1124		
1954	Typhoon Toyamaru	1761		
1958	Typhoon Kanogawa	1269		
1959	Typhoon Ise-Wan	5098		
1966			Illinois Heat Wave	1148
1986			New York City Heat wave	1001
1995	Great Hanshin-Awaji Earthquake	6437		
2005			Hurricane Katrina	Approx. 1833
2011	Great East Japn Earthquake (Tsunami)	21839		

8.1.2 Mega Disasters and Ordinary Disasters

It is true that the reduction in damage form natural disasters in the postwar period was the result of a variety of disaster reduction efforts. However, these measures were effective against only minor and medium-sized disasters-that is, ordinary disasters – not mega disasters. In the 20 years after World War II, and average of about 700 people died per year from ordinary disasters, but in the most recent 20 years, that number has fallen to 100. Thus, the effects of disaster reduction measures are clearly visible, but it is equally obvious that the number of victims of mega disasters is not decreasing.

8.1.3 Mega Disasters in the Future

Mega Disasters will never disappear. Even if we look only at the years since 1900, mega disasters have occurred at a frequency of about once every five years somewhere in Japan. Furthermore, 12 mega disasters have been caused by storms and floods, as opposed to 10 mega earthquake and tsunami disaster: ratio of six to five.

In Japan, the concentration of the population in the three major urban areas of Tokyo, Osaka, and Nagoya has increased the vulnerability of our society to natural disasters as never before. Moreover, it is believed that global warming will cause typhoons to decrease in frequency but increase in size. Japan needs to prepare for storms and floods such as we have never experience before.

Obviously, Japan must continue to be vigilant about mega earthquake and tsunami disasters. Japanese governments are anxiously assuming that two mega earthquakes will occur in the near future: a mega earthquake along the Nankai Trough and one directly under Tokyo. These two mega earthquakes will cause damage that is not only massive but also widespread. More work is needed to clarify the realities of the affected communities of wide-area mega disasters and to deepen our understanding of these mega disasters. Furthermore, Japan is now in a seismically active period; hence, intraplate earthquakes in all parts of the country are possible. Incidentally, in the previous seismically active period in western Japan, there were seven major disaster owing to intraplate earthquakes, including the Kita Tango Earthquake (1927), the Tottori Earthquake (1943), the Mikawa Earthquake (1945), and the Fukui Earthquake (1948).

8.2 Mega Tsunami Disasters: The Great East Japan Earthquake

The Great East Japan Earthquake brought about the second mega tsunami disaster of the postwar period in Japan. The first was the 1946 Nankai Earthquake and Tsunami, which left 1,330 people dead or missing. From the viewpoint of local governments' disaster responses and the affected communities, the main features of a mega tsunami disaster are

- Long-term flooding damage: refers to seawater inundation of cities and towns, which is not discharged and remains as standing water.
- Planar damage
- Wide-area damage
- Missing people

In this event, the long-term flooding trapped many local officials and residents in inundated areas, causing delays in local governments' disaster response. This case demonstrates that the delay in initiating the disaster response led to delays in each subsequent phase of the response. Many other disaster responses were also affected because societal functions within the inundated areas were lost owing to planar damage, and the demand for disaster relief grew enormously and became decentralized because of the wide-area damage. Furthermore, investigators and residents seeking missing family members and friends wandered through the flooded area where they were exposed to possible secondary threats from harmful substance or explosive. In addition, because it was impossible to confirm the number of dead and missing people in the early days after the tsunami, local governments encountered obstacles in dealing with victims' bodies.

8.3 Developing Strong Structures Against a Mega Tsunami

1) Why RC buildings were Overturned due to the Tsunami

Pile-supported reinforced concrete (RC) buildings were uplifted and overturned due to the 2011 Great East Japan Earthquake and Tsunami. This kind of building damage had been reported only once before: the lighthouse overturned by the 1946 Aleutian Tsunami. Multistory RC buildings, especially pile -supported ones in the tsunami inundation zone, had been expected to serve as evacuation buildings for people. Therefore, it is important to understand the mechanism that causes such damage so that we can build coastal communities that are able to withstand a mega tsunami.

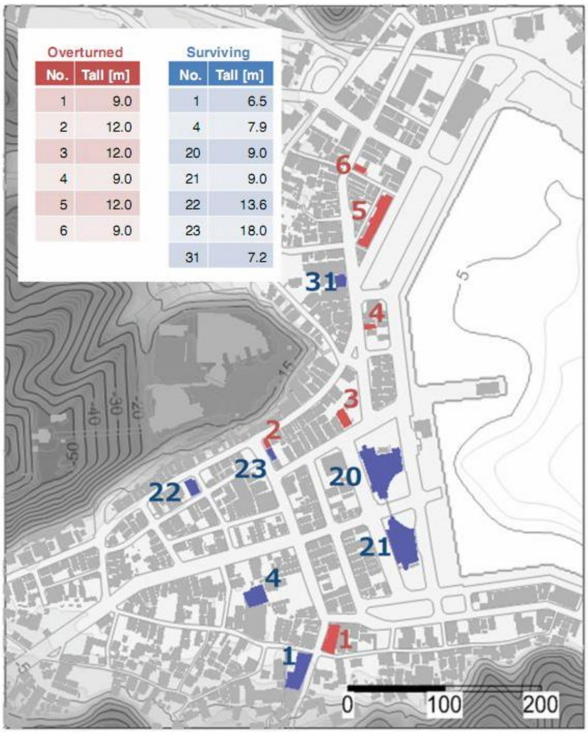

Figure 8-1 Location of target buildings and their height (Okumura et al. 2015)

The result from studied of the tsunami hydrodynamic force (Fig.2) for each building, was not a large difference in the calculated tsunami force per unit width between the buildings in the overturned group and those in the surviving group. So, next studied, they carried out a stability analysis by comparing the overturning moment and the resisting moment for each building, as shown in Fig.3. The result from this studied suggest that the pile resisting moment makes a significant contribution resistance for most of the overturned buildings, but not for the surviving buildings. Their analysis does not explain the behavior of every building. However, it does indicate that the pile foundations of most overturned buildings made a critical contribution to resist the tsunami flow. The failure of these piles, either because of the tsunami hydrodynamic force of the strong ground motion, led to their being overturned. On the other hand, most surviving buildings could resist the tsunami flow though only their self-weight.

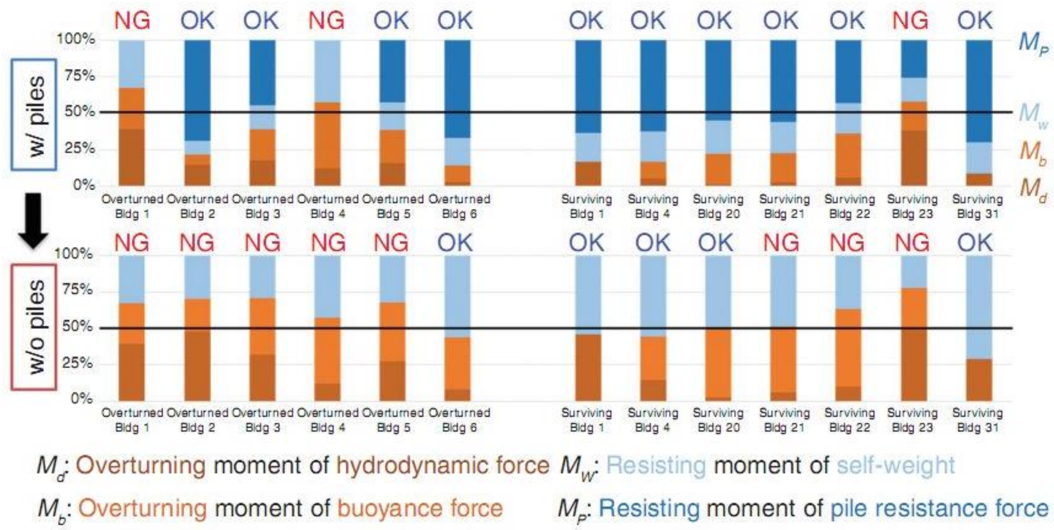

Figure 8-2 Hydrodynamic force per unit width for each building (Okumura et al. 2015)

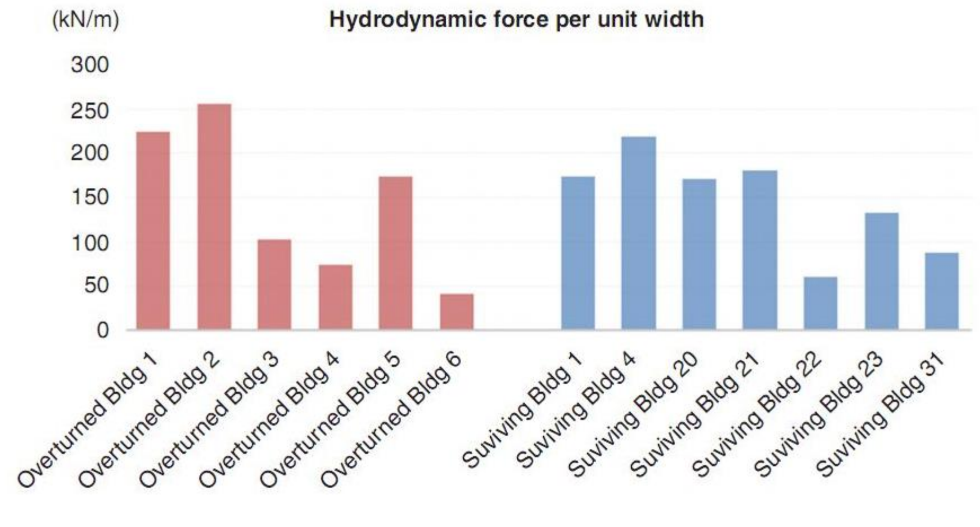

Figure 8-3 Comparison of the overturning moment and the resisting moment for each building (top: including pile resistance; bottom: ignoring pile resistance) (Okumura et al. 2015)

2) Resiliency through Structural Design

The development of infrastructure that is resilient to a tsunami requires a multi-pronged approach. One aspect is resiliency through structural design. This means that the structures – for example, buildings, bridges, and industrial facilities – are designed such that they have sufficient "resistance" for the "demands" exerted by the tsunami to achieve a certain "performance level". It is first helpful to clarify what structural designers mean by "performance level", "demand", and "resistance". The definitions apply to all types of loading, including tsunami, earthquake, and wind.

There are no such general specifications for tsunamis that structural engineers can rely on. They summarize the approach taken in the United States to provide structural engineers with such guidance. The three most fundamental types of demands involve the hydraulic force – that is, the force directly applied by the fluid and its flow – the impact from the debris driven by the flow, and the scour of the ground, which weakens the structural foundation. For all of these, the designers need to know the water depth and associated velocity to calculate the associated demands.

8.4 Evacuating from a Mega Tsunami

Evacuation for a Tsunami That Exceeds Assumptions

It is difficult to deal with mega disasters by relying solely on experience. Before the Great East Japan Earthquake, the worst scenario tsunamis were based on records from the previous approximately 400 years. However, the height of the tsunami that actually occurred in 2011 was two to three times more than the assumed worst-case scenario. They are now focusing on the difficulty of evacuating for a tsunami that exceeds expectations and looking into preparing society to deal flexibly with such events.

It is not easy to set up measures against tsunamis in areas outside the expected inundation areas in normal times. People outside the expected inundation zone believe that they are safe, that they will not need to go to higher ground. In elderly care facility in the town of Minami-sanriku, as part of a project in caregiving education and intergenerational exchanges, stairs had been installed between the facility and a high school that was located on still higher ground. These stairs were the only route to higher ground from the facility, and if they had not been there, the worst might have happened. They must study the lessons learned in the Great East Japan Earthquake in order to create a society that can respond flexibly to unexpectedly large tsunamis. Links between education, welfare, tourism, and other fields will be key factors in promoting such development.

8.5 Surviving Sever Conditions after Evacuation from a Mega Tsunami

1) The Nankai Trough Earthquake: Projected at 10 times larger than the Great East Japan Earthquake

In August 2012, in the wake of the Great East Japan Earthquake, the Japanese government published new worth-case tsunami scenarios in response to worries about the probable near-future interpolate earthquake along the Nankai Trough. A disaster much larger than previous assumptions in now assumed, and the expected earthquake has been named the Great Nankai Tough Earthquake. Worst-case scenarios assume as many as 300,000 dead or missing under current conditions. After the earthquake and tsunami, harsh living conditions after evacuation may lead to deaths not directly caused by the earthquake and tsunami. They need measures to ensure that people whose lives have been saved by fleeing from a tsunami do not then lose their lives afterwards owing to poor living conditions after they evacuate.

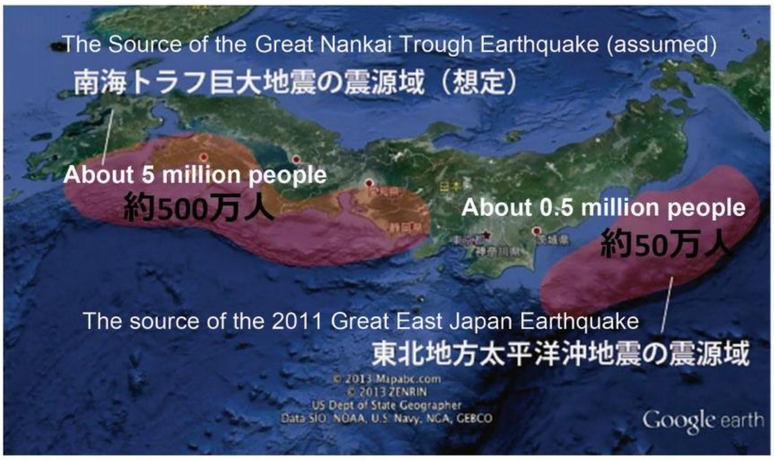

Figure 8-4 The Sources of the Great Nankai Trough Earthquake and the 2011 Great East Japan Earthquake

2) Independent Disaster Relief Efforts

The Great East Japan Earthquake offers us hints for surviving the future Great Nankai Trough Earthquake, which may produce as many as 10 times the number of affected people. For example, in the city of Tahara, some communities are carrying out experiential learning in evacuation shelter life at each school district. Some places are already at work on municipal and regional plans aimed at helping them survive a wide-area mega disaster. In the town of Kushimoto in Wakayama Prefecture, the hospital has been moved to higher ground and the local government offices to higher ground as well. Moving the important municipal functions to higher ground is part of the systems that towns are setting up in order to protect themselves.

8.6 Sustainable Disaster Reduction System for Mega Tsunami Disaster

The key to confronting disasters that happen only once every several hundred years or several thousand years is sustainability. As an example. Let us look at measures in the city of Minami-Awaji, assumed to be the city that would experience the largest tsunami in Hyogo Prefecture. About six months after the opening of the Fukura Tsunami Disaster Prevention Station in September 2010, the Tsunami Disaster Prevention Station Administration Council was formed. Instead of limiting their activities because of disaster reduction, they set for themselves an easily shared goal of revitalizing Fukura as the Japanese town most prepared for a variety of people to participate. By adding tsunami disaster prevention measures to diverse regional community activities, they have increased opportunities for people in fields other than disaster prevention to take an active role in preparing for a tsunami. It is expected that sustainable and continuous mechanisms for dealing with tsunamis will be constructed in the region. We should think about the future of disaster prevention and disaster reduction along three broadly defined lines:

- How to minimize the damage from mega disasters
- How to maintain current levels of disaster prevention and disaster reduction
- How to reduce the annual number of disaster victims from 100 to 0

Currently, rainfall patterns are becoming more extreme. It is quite possible that we will see more unprecedented amounts of rainfall, such as that which occurred with Typhoon No. 18 in September 2013. The ability to deal with not only mega disasters but also every kind of unprecedented disaster will be required at the personal, regional and national levels.

8.7 Mega Disaster in Thailand

Some example of mega disaster in Thailand is tsunami, 2004. The 2004 Indian Ocean earthquake occurred on 26 December, with a center off the west coast of Sumatra, Indonesia. This earthquake has a moment magnitude of 9.1–9.3 and a maximum Mercalli intensity of IX (*Violent*) which is the third-largest earthquake ever recorded on a seismograph and had the longest duration of faulting ever observed, between 8.3 and 10 minutes. It was an undersea megathrust earthquake caused by rupture along the fault between the Burma Plate and the subducting Indian Plate. The 2004 Indian Ocean earthquake triggered a series of devastating tsunamis up to 30 meters (100 ft) high, inundating coastal communities along the coasts of the Indian Ocean and killing an estimated 227,898 people in 14 countries. The earthquake was one of the deadliest natural disasters in recorded history, the deadliest of the 21st century so far. Indonesia was the hardest-hit country, followed by Sri Lanka, India, and Thailand. This event is known by the scientific community as the Sumatra–Andaman earthquake.

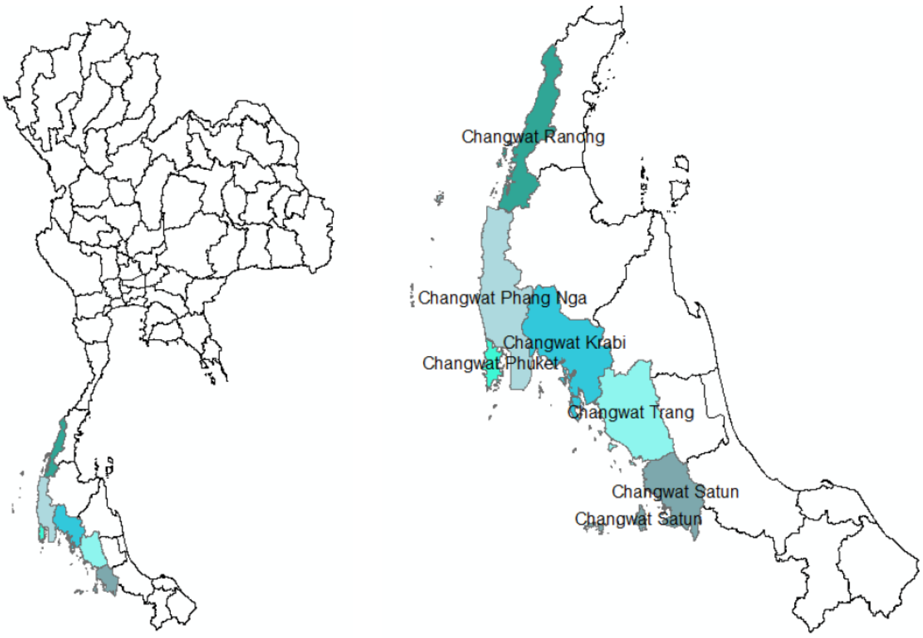

Figure 8-5 Affected area of the 2004 Indian Ocean earthquake in Thailand

For Thailand, the earthquake was felt in many provinces along Andaman coast. The tsunami hit the southwest coast of southern Thailand, which was about 500 km (310.69 miles) from the epicenter. The region is heavily visited by foreigners during the Christmas season. Since the tsunami hit during high tide, its damage was severe. Approximately 5,400 people were killed, 3,100 people were reported missing and 8,500 people were injured from that disaster. The places where the tsunami struck were Phang Nga Province, Phuket, the Phi Phi Islands, Ko Racha Yai, Ko Lanta Yai and Ao Nang of Krabi Province, offshore archipelagos like the Surin Islands, the Similan Islands, and coastal areas of Satun, Ranong, and Trang. All these places are tourist attraction, so a lot of tourist would go to those places and it leaded to be a mega disaster.

Figure 8-6 Damage of Tsunami on Phi Phi Island, Krabi province, Thailand in 2004

The most damage sector from this Tsunami in Thailand was tourism because the beach in Andaman coast is very popular place of tourism. A lot of resorts along the Andaman Sea coast have been extensively damaged. Moreover, more than 500 fishing boats have been destroyed, as well as many piers, and free willy and fish-processing facilities. However, Thai government provided large amount of capital to enable the recovery of the private sector.

Figure 8-7 Damage of Tsunami on southern part of Thailand in 2004

The reasons why more over 1,000 people was killed at once consist of

1. The area where Tsunami hit is in the southwest coast of southern Thailand. This area is a popular area for the tourist, so there are many tourists in that area during the disaster.
2. Tsunami occurred on 26 December 2004. This duration was the high season for traveling because it was a long weekend for Christmas and New Year.
3. The wave height is very high around 10 meters. However, most of buildings around the damage area was not high. Therefore, the building cannot resist so it collapses and was taken to the water. A lot of people cannot evacuate or escape to the high space. Most people died from drowning and attacked from building ruins.
4. Thailand had not encountered with Tsunami before, therefore they did not know what will happen after the earthquake occurred under the sea. After the sea water was very, a lot of people felt interested in that phenomena and only observed that phenomena. Thus, when Tsunami hit the coastal area, a lot of people were died by that disaster.
5. There were not Tsunami warning system in that duration because we had not encountered with Tsunami before.

8.8 Conclusion & Recommendation

Japan has experienced an unprecedented series of natural disasters. The 2011 Great East Japan Earthquake and Tsunami, which left up to approximately 20,000 people dead or missing, was a massive event, the largest tsunami in over 1,000 years of tsunami history in Japan. On August 30, 2013, a new emergency warning system was launched by the Japan Meteorological Agency (JMA). This special warning alerts people to the significant likelihood of unprecedented catastrophes in association with natural phenomena of extraordinary magnitude. Just a couple of weeks after, this warning was used for the first time. Heavy rains accompanying Typhoon No.18 caused major damage, particularly in Kyoto. The Katsura River flooded, with muddy torrents swallowing the popular tourist destination pf Arashiyama, which a number of travelers from around the world visit daily.

Because Japan is apparently in an era of seismic activity and tendencies toward extreme weather and climatic events, the Japanese must confront natural disasters, unlike and they have experienced before, in their daily lives. This chapter explains the characteristics of mega disasters and the difficulties of dealing with them with reference to actual disasters from the past. The objective is to minimizing future mega disasters, along with specific examples from the research and community programs.

However, if we prepare a large measure for the uncertainty of the disaster, we may lost a lot of money and don’t have any advantages from that structure. Therefore, we should the good disaster risk management before prepared countermeasures.

Chapter 9
Water resource management under a changing climate

9.1 Hydrology and Water Resources Engineering

"Hydrology is the science which deals with the waters of the earth, their occurrence, circulation and distribution on the planet; their physical and chemical properties and their interactions with the physical and biological environment, including their responses to human activity. Hydrology is a field which covers the entire history of the cycle of water on the earth. (UNESCO International Hydrological Decade, 1964)"

"Water is the source of all life on the earth and is an indispensable resource of human social and economic activities. The water cycle and its temporal and spatial distribution depend on solar radiation, topography, and various conditions of the earth's surface. Hydrology provides understanding of the physical processes of water movement and the foundations for proper use and protection of water resources. (Maidment, 1993)"

9.1.1 The Science of Water cycle: Hydrology

Water circulates on the earth due to solar and gravitational energy, and changes its phases (ice, liquid, and vapor). Hydrology clarifies the movement of water and distribution of water in time and space on and beneath the earth's surface, involving transports of sediment, dissolved nutrients, and contaminants. The water cycle is associated with the energy cycle. When soil moisture on the ground surface evaporates and changes phase from water to vapor, the latent heat moves from the earth's surface to the atmosphere. When the vapor changes to raindrops, the latent heat is released to that atmosphere as condensation heat. Thus, the solar energy provided to the earth's surface is transferred to the atmosphere through evaporation and precipitation. The solar energy reaching the earth's surface is spatially and temporally distributed, and determines the climate. The water and energy cycles are closely related to climate and the spatiotemporal distribution of water.

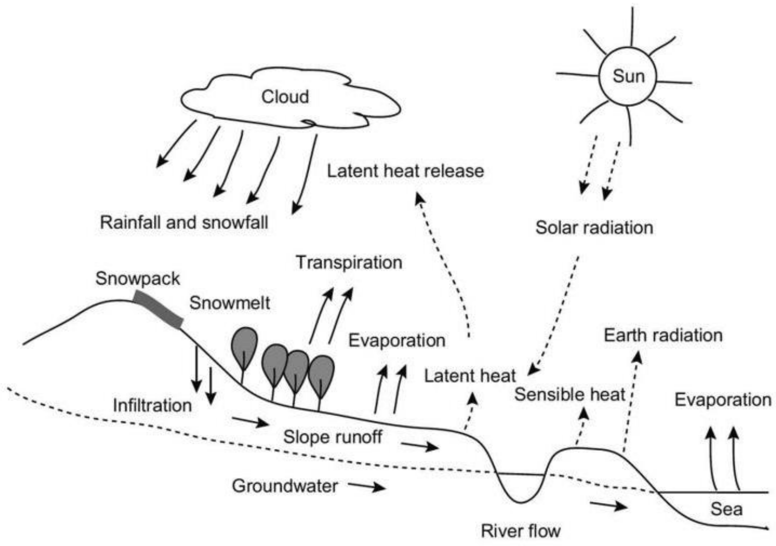

Figure 9-1 Hydrologic processes and water and energy movement with change of water phase

Water movement causes the movement of soils and chemical substances dissolved in water. These movements are closely associated with our lives and the environment. Therefore, the scope of hydrology includes the cycles of water and energy, and the physical, chemical, and biological processes associated with these cycles.

9.1.2 Hydrology as a Science and a Profession

The first aspect relates to questions about how the earth works, and specifically about the role of water in natural processes. The second aspect is the main theme of water resources engineering. The research topics include: flood and drought, flood risk management, water resources management, and climate change and water resources.

9.2 Global Water Balance

To discuss the spatiotemporal distribution of water, consider a closed compartment (referred to as a control volume) shown in Figure 9.2. M_{in} is the rate of mass flowing into the control volume, M_{out} is the rate of mass flowing out of the control volume, and M is the mass stored in the control volume. The equation of the conservation of mass is given by

$$\Delta M=\left(M_{in}-M_{out}\right)\Delta t$$

$$\Delta V=\left(I-O\right)\Delta t$$

$$\frac{dV}{dt} = I - O$$

ΔM	=	change of water mass in the control volume over time Δt
ΔV	=	volume of the water stored in the control volume
I	=	volume inflow rate
O	=	volume outflow rate

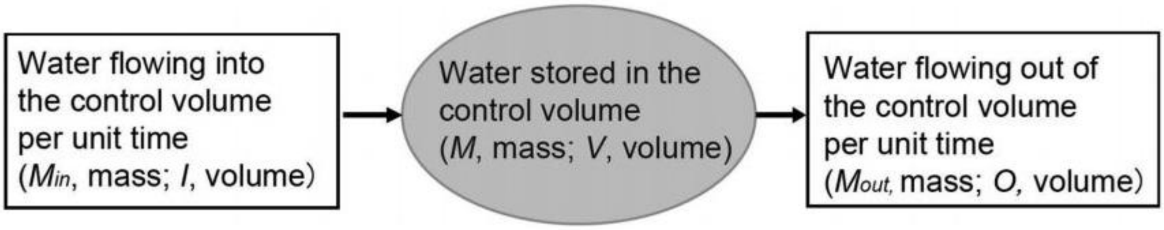

Figure 9-2 Water balance and continuity relation

9.3 Catchment Water Balance

A catchment, as shown in Figure 9.3, is and area in which rainwater drains into a channel network (river network) and finally flows to the river mouth. A catchment is separated by a topographically defined water shed boundary. Consider A is the area of a catchment basin, r is the precipitation rate (volume of precipitation falling on the catchment basin per unit time per unit area), e is the evapotranspiration rate (the volume of water evaporating per unit time per unit area), and Q is the runoff flowing out of the catchment. The inflow rate into the catchment I is I = Ar, and the outflow rate is $O = Ae + Q$ and equation in the catchment is defined as:

$$\frac{dV}{dt} = A(r - e) - Q$$

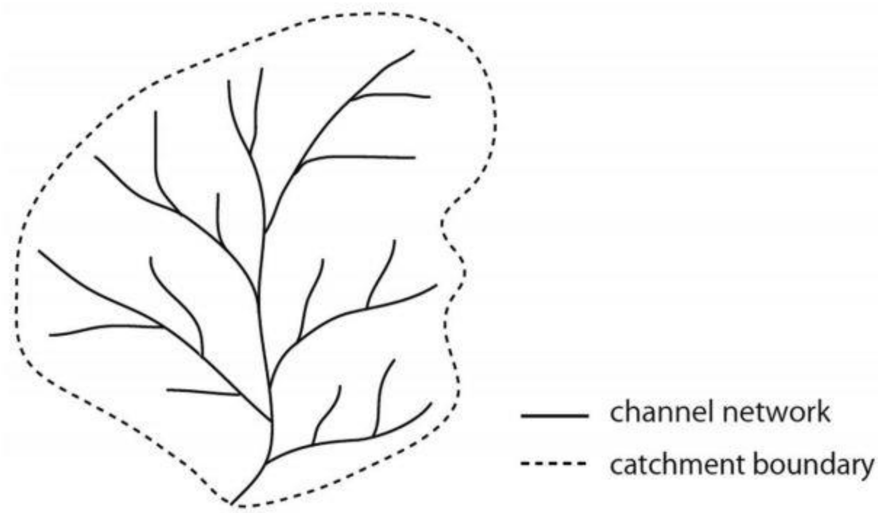

Figure 9-3 Watershed divide and catchment basin

9.4 Water Resources Prediction under Changing Climate

River Flow Prediction in Indochina Peninsula under climate change

General circulation models (GCMs) provide future atmospheric and hydrologic variables under various climate change scenarios. The output hydrologic variable is used for various applications of future hydrologic projections to evaluate future water resources under a changing climate. River discharge projection in the Indochina peninsula region using the outputs of MRI-AGC3.2S which developed by the Meteorological Research Institute of the Japan Meteorological Agency. The products of MRI-AGCM3.2S consist of various atmospheric and hydrologic variables for the present climate experiment. Daily mean discharge and maximum hourly discharge in a day were compiled using 5-minute spatial resolution, which was analyzed to determine river basin with significant changes of water resources, floods, and droughts.

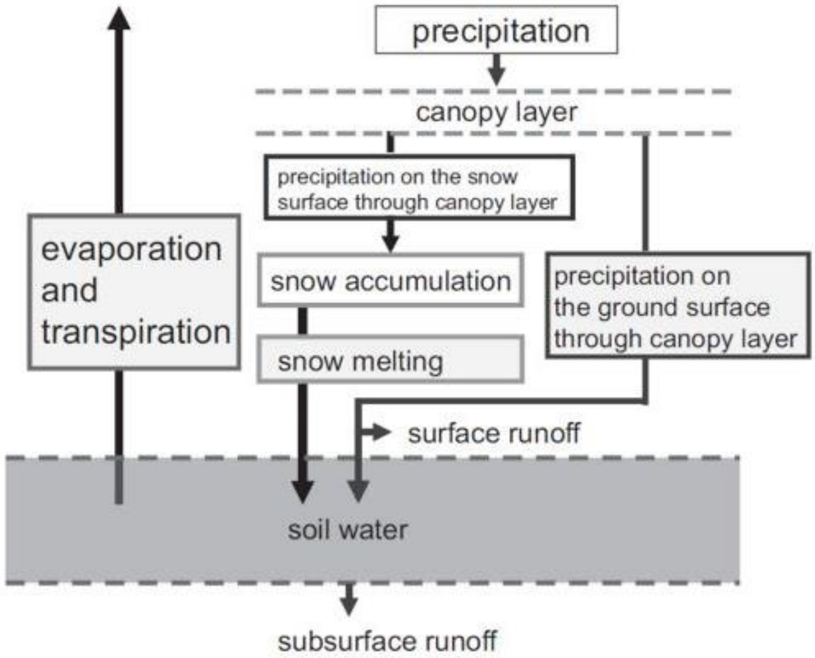

Figure 9-4 GCM outputs related to the hydrologic cycle in the MRI-AGCM

9.5 Conclusion & Recommendation

Hydrology is the science which deals with the waters of the earth, their occurrence, circulation and distribution on the planet; their physical and chemical properties and their interactions with the physical and biological environment, including their responses to human activity. Hydrology is a field which covers the entire history of the cycle of water on the earth. Water is the source of all life on the earth and is an indispensable resource of human social and economic activities. The water cycle and its temporal and spatial distribution depend on solar radiation, topography, and various conditions of the earth's surface. Hydrology provides understanding of the physical processes of water movement and the foundations for proper use and protection of water resources. The main equation in the water resources management is water balance equation. For example, managing the dam using this equation to balance and manage the dam in order to supply the people or flood reduction.

The water resources management in Thailand widely used in the country especially for the dam management. This situation need to manage the water resource for supply and flood control for the people in Thailand. Thailand got a lot of floods in the country which make a lot of loss especially economic loss in 2011. Water resources management is necessary issue for Thailand.

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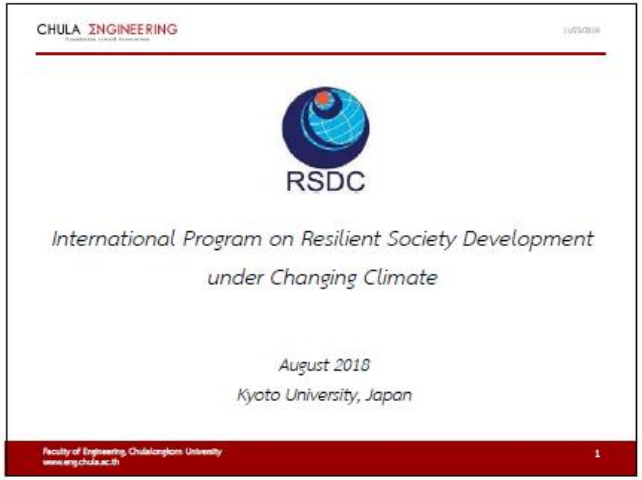
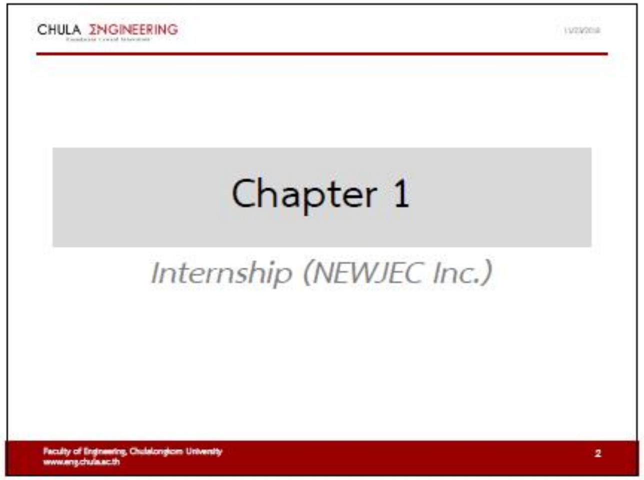
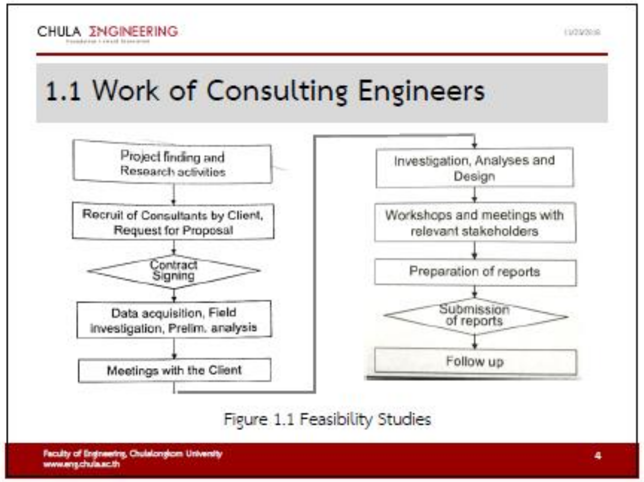






1.2 Japan Response to Flood

1) Dissemination of risk information

    Hazard map

2) Preparation and training for evacuation

3) Improvement of flood prediction

1.3 NEWJEC's Flood management Technologies

1) Ground Surface Inundation Simulation
2) Underground Inundation Simulation
3) Evacuation Simulation

Chapter 2

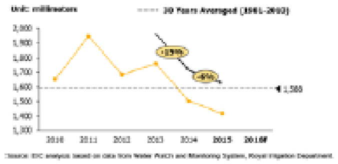
Climate Change

2.1 Climate Change Indicators

Past Decade Warmest on Record According to Scientists in 48 Countries, NOAA, July 28, 2010

Thailand

- Drought
  - Thailand has experienced drought episodes almost every year, including the current one. This year, the agricultural sector will bear the largest impact, as the quantities of many agricultural products fall, especially rice, tapioca, sugarcane, and sugar. However, agricultural supply shortages may lead to price improvements for some crops.

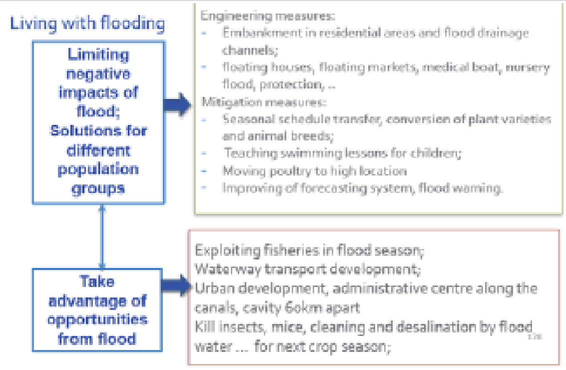


- Flood
  - Red River delta: Upstream
  - Mekong River delta: water level of over 4.5 m. in 2000, 2001, 2011
  - The central Vietnam

High Vulnerable areas

- Other extremes
  - Cold days in the North decrease.
  - More extreme cold days

Climate change response



Adaptation

1. Development of weather, disaster, CC forecasting, warring systems
2. Improving natural (forest, mangrove, wetland,...) and social (infrastructure, HR, governance, land use planning...) resilience

- Adaptive economy and livelihood: change crop and season of agriculture; development of less vulnerable sectors
- Reservation of water, foods, medicals…for emergencies

Mitigation

1. Using water, wind, solar energy
2. Efficient use energy, water (VAC...)
3. Low GHG emission economy: agriculture, energy,...
4. 3R of waste for energy (biogas, making gas from agriculture waste...), ...

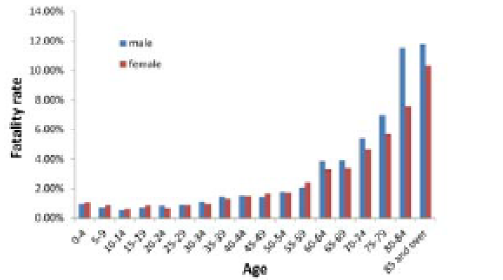
Using CC opportunities

1. Living with flood, drought, CC
2. Increasing biological mass and productivity
3. Development of brackish ecosystem based economy and livelihood
4. Warming water from global warming
5. Climate smart models; new collaboration

Chapter 3

Countermeasures against Natural Disasters Based on Human Diversity

- Generally, as a nation or region is increasingly developed and improved, the demand for social systems based on residents' diversity rises.
- we describe countermeasures against natural disasters based on the diversity of local residents such as aged people, people with disabilities, women, foreigners etc.



Fatality rate of three prefectures extensively damaged by the Great East Japan Earthquake (Iwate, Miyagi, and Fukushima) by age group

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Aging and Countermeasures against natural disasters

- In the world, many countries' populations now trend to be aging due to longevity brought about by improved medical services and public sanitation.
- United Nations' estimate other Asian countries that will also be rapidly aging in the future.

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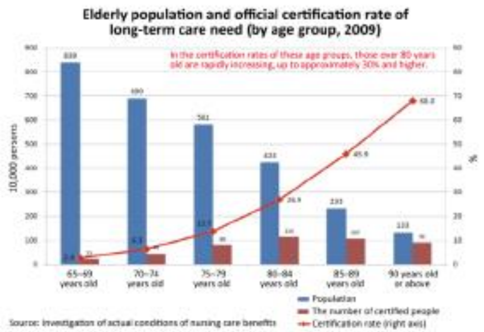

Japanese elderly population and official certification rate of long-term care need (Ministry of Health, Labour and Welfare)

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Evacuation center during the Great East Japan Earthquake

Foreigners and disaster prevention measures

- The main challenge for foreigners during a disaster is language.
- the Japan Center for International Exchange and International Association are affiliated organizations to help foreigners.
- Currently, the Kyoto City government prepares an "Escape guiding plan for travelers who have difficulty in returning home.

Natural Disaster in Thailand.

Thailand Flooding, 2011

Countermeasures against flooded in Thailand(2011)

- In 2011, Thailand got a very big flooding in Chaophraya river basin. This disaster is ranked by the world bank that is the 4th rank of the economics loss in the world.
- After this disaster, government help the victims by finding some place such as school, university, temple and official place for living during disaster.

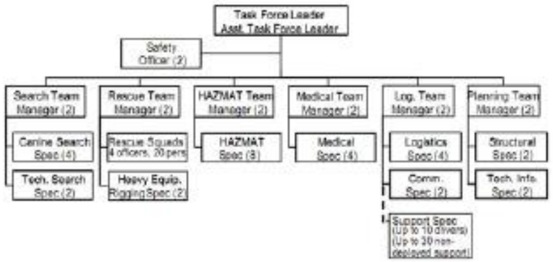
Chapter 4

International/National US&R systems in UN, US, UK and Japan.

- Urban Search and Rescue (US&R) is issue in disaster preparedness.
- to save the lives of victims trapped in structures or buried in debris at sites of catastrophic disasters.

National US&R response system in USA

- The Federal Emergency Management Agency (FEMA) established the National Urban Search and Rescue (US&R) Response System in 1989 .



US&R task force team organization chart

Photo 2 Multilift hook-lift loading system **Photo 3** Loading motion

Photo 4 Multi-Purpose Vehicle

vehicles in each USAR Unit

Trials towards establishing US&R system in Japan.

- In Japan, US&R response teams are not established .
- But they have multidisciplinary US&R team of Japan is the Japan Disaster Relief team (JDR). which is an international US&R response team to respond to overseas disasters.

Photo 7 Emergency Fire Response Teams **Photo 8** Police Emergency Rescue Units Assistance Teams **Photo 9** Disaster Medical

US&R teams(Thailand)

- In Thailand still does not has US&R teams
- But when Thailand face disaster the one who come to rescue may be military army. For example in the case of Tham luang cave.

Seal(navy)

Chapter 5

Multi-disciplinary disaster response operations and training designs

A case study: 2005 Amagasaki train crash, Japan

- That incident happened on April 25, 2005.
- A speeding Rapid Service seven-car commuter train jumped off the tracks and crashed into an apartment building.
- 107 people were died .

Amagasaki train crash site

Materials and method of the case study

- To do literature surveys from Hyogo prefecture, Amagasaki Fire Department, Japanese Association of Disaster Medicine, and others.
- Analyzing record of location and time data of all ambulance from Amagasaki Fire Department.
- Plotting map of people, vehicles, tents and other resources deployed in response to this disaster from aerial photos and videos of the site from helicopter team.

Official remarks in the report on features of the disaster and its management

1) The good points of this disaster and its response

- The time of outbreak of disaster: It occurred on a weekday (Monday) at a new shift time at 9.18 am for many responding organizations and agencies.
- Many Responding organizations and agencies, including municipalities, established an Emergency Control Center (ECC) very quickly
- Many Responding teams hurried to the site and reached it very quickly.

The bad aspects of the disaster and its response

- Many casualties over a limited area.
- The disaster site was split into two by the railroad: the railroad also separated the communications of the two sides.
- On the day of the accident, these was concern that the apartment building might collapse.
- The underground parking of the building was closed because of gasoline leakage. Equipment recuse might produce sparks, so it took much longer to rescue people.

The aspect of disaster site at each scale dimension.

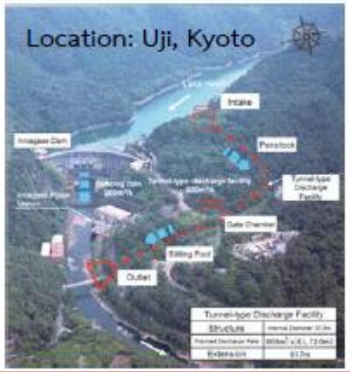
A doctor entering the confined space to provide medical support (left) and patient with only a partial access (right)

Chapter 6

Amagase Dam & Lake Biwa museum

Field Trip

Amagase Dam



History

- In the past, areas around Lake Biwa and the Uji River have often suffered **damage from flooding**
- Strengthen the **flood control** functionality with the Amagase Dam Redevelopment Project.

○ Damage caused by Typhoon No. 13 in September 1953

State of flooding of Uji River
(near Kumiyama-cho, Kuse-gun, Kyoto)

○ Damage caused by the seasonal rain front in May 1968

State of inundation damage around the coast of Lake Biwa
(near Higashiomi City, Shiga)

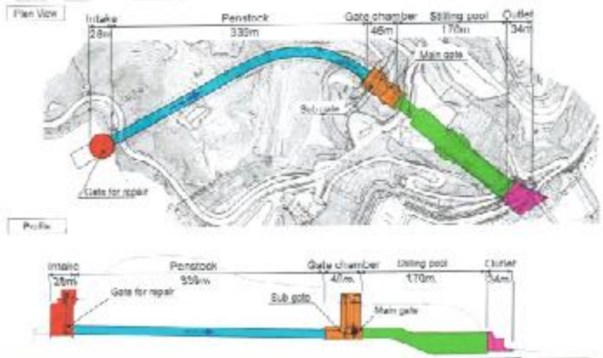
Developments of the Amagase Dam Redevelopment Project

1953	The dam received massive damage by Typhoon No.13
1954	The Basic Plan to Repair the Yodo-gawa River System was finalized
1964	The Amagase Dam was completed
1965	The dam received tremendous damage by flood caused by typhoons including Typhoon No. 24
1969	Kyoto Prefectural Waterworks requested the increase of 0.6 m^3/s
1971	The Yodo-gawa River System Construction Implementation Basic Plan was revised
1972	The Kansai Electric Power Co., Inc. requested the increase during the summer
1975	Preliminary research was started
1989	Construction was started
1995	The Basic Plan was formulated (Notification No. 996 of the Ministry of Construction)
1997	The River Act was revised
1998	Construction of road used for construction was started
2007	The Basic Policy for River Improvement of the Yodo-gawa River System was established
2009	The River Improvement Plan of Yodo-gawa River System was formulated
2013	Tunnel construction was started
2018	The Amagase Dam Redevelopment Project will be completed

Objective

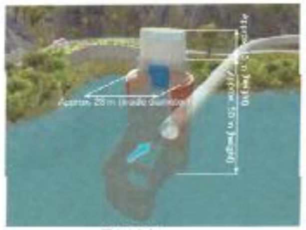
- **Water control :**
  - improvement in the function of flood control
  - The discharge capacity will in **increased** from 900 m^3/s to 1,500 m^3/s
- **Water utilization :**
  - enhance **power generation capacity** at Kisenyama Dam
  - Ensure water for the **water supply** in Kyoto

Design

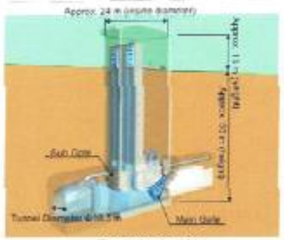


Design

Illustrations



The intake



The gate chamber

Lake Biwa Museum

Important of Lake Biwa

- As a water Sources
- For fishing
- As tourist and recreation locations
- As biodiversity conservation areas (catfish)
- As Natural Balance Preserving Reservoirs

Exhibition rooms

- Geological History
- Human History
- Nature Connection with our Lifestyles
- Aquarium
- Discovery room
- Outdoor exhibits

Exhibition rooms

- Geological History

Exhibition rooms

- Human History

Life in the Jomon Period: Hunting and Gathering

Products transported from northern areas of Japan to Otsu in the five years from 1778

A maruko-bune boat

Exhibition rooms

- Nature Connection with our Lifestyles
- Aquarium

Chapter 7

Advancement on humanitarian logistics

Humanitarian Logistics

Figure 8.1 Kobe Earthquake (1995)

Meaning of logistics

Business Logistics	Humanitarian Logistics
▪ Cost minimization ▪ Profit maximization ▪ Customer's Satisfaction	▪ Coverage maximization ▪ Delay minimization ▪ Equity ▪ Cost effective

Factors considered in transport

- Characteristic of goods
- Environmental issue: Climate, taxes
- Available capacity of transport
- Origin and destinations
- Quantity of distribution centers
- Available human resource

Vehicle Routing and Scheduling

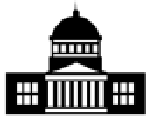
Objective	Constraints
Maximize vehicle utilization	Driver's driving time is limited
Minimize the distance travelled	Capacity of the delivering vehicle is fixed
Meet the requirement of customer: cost, service time	Limited number of visits at each delivery point

Humanitarian Logistics Modelling

Objective Function

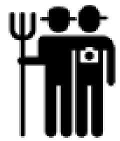
- Minimize penalty of total shortage of supply
- Minimize total routing cost

Coordination in Humanitarian Logistics


Government


Foreign Countries


Military


Local Community


Donation


Shipping Company

Chapter 8

Toward a Resilient Society Against a Mega-Tsunami Disaster

Mega Disaster

- Is enormous events in which **1,000 or more people** died or went missing at once
- There have been 22 mega disasters in japan and 8 mega disaster in US. Since 1900
- In Japan 12 Mega disasters have been caused by storms and floods, other 10 mega disaster is earthquake and tsunami

Mega Tsunami Disasters: The Great East Japan Earthquake

Year	Disaster	Number of Deaths and missing Persons
1944	Tonankai Earthquake	1,251
1946	Nankai Earthquake (Tsunami)	1,330
2011	Great East Japan Earthquake	21,839

The main features of a mega tsunami disaster are

- Long-term flooding damage
- Planar damage
- Wide-area damage
- Missing people

Resiliency through structural Design

- United States provide **Tsunamis** engineer structural guidance about fundamental **types of demands** involve
  - the hydraulic force ,
  - the impact from the debris driven by the flow
  - the scour of the ground.

Sustainable Disaster Reduction System for Mega Tsunamic Disaster

The future of disaster prevention and disaster reduction should be along three broadly defined lines

- How to **minimize the damage** from mega disasters
- How to **maintain current levels of disaster prevention and disaster reduction**
- How to **reduce the annual number of disaster victims** from 100 to 0

Mega disaster in Thailand

- tsunami, 2004

Mega disaster in Thailand

- Tsunami hit is in the **southwest coast of southern** Thailand.
- Tsunami occurred on 26 December 2004. This duration was the **high season**
- The **wave height is very high** around 10 meters. However, most of **buildings** around the damage area was **not high**
- Thailand had **not encountered with Tsunami before**
- There were **not Tsunami warning system** in that duration

Chapter 9

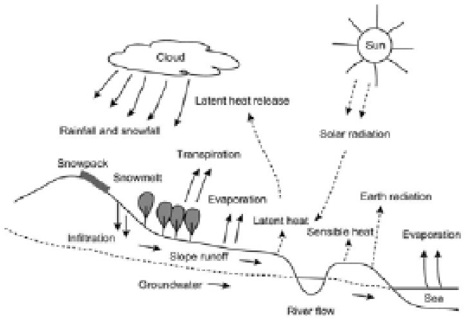
Water Resource Management under a changing climate

Hydrology and Water Resources Engineering

- "Hydrology is the science which deals with the waters of the earth, their occurrence, circulation and distribution on the planet; their physical and chemical properties and their interactions with the physical and biological environment, including their responses to human activity. Hydrology is a field which covers the entire history of the cycle of water on the earth (UNESCO International Hydrological Decade, 1964)"

"Water is the source of all life on the earth and is an indispensable resource of human social and economic activities. The water cycle and its temporal and spatial distribution depend on solar radiation, topography, and various conditions of the earth's surface. Hydrology provides understanding of the physical processes of water movement and the foundations for proper use and protection of water resources (Maidment, 1993)

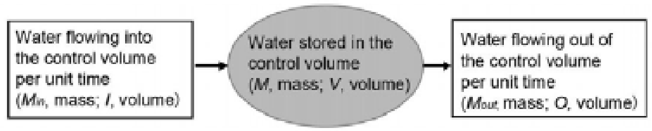
Hydrologic processes and water and energy movement with change of water phase.



Water balance and continuity relation

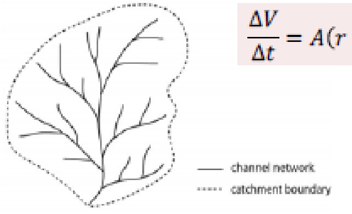
$\Delta M = (M_{in} - M_{out})\Delta t$ $\quad \Delta V = (I - O)\Delta t$ $\quad \dfrac{dV}{dt} = I - O$

ΔM = the change of water mass in the control volume over time Δt
ΔV = the volume of the water stored in the control volume
I = the volume inflow rate
O = the volume outflow rate



Catchment water Balance

- A catchment is separated by a topographically defined water shed boundary.



$$\frac{\Delta V}{\Delta t} = A(r - e) - Q$$

A = area of catchment
ΔV = the volume of the water stored in the control volume
r = precipitation rate
e = evaporation rate
Q = runoff flowing out to the catchment

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