# CATASTROPHIC FLOODS

## Hidden Vulnerability of Mega Cities


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# PREFACE

The United Nations is convening a World Conference on Disaster Reduction in Kobe, Japan from the 18th to the 22nd of January 2005.

As an event leading to the world conference, the United Nations University (UNU), Cabinet office of Japan, United Nations International Strategy for Disaster Reduction (UN-ISDR) and Asian Disaster Reduction Center (ADRC) have organized a public forum on 23rd March 2004, titled *Catastrophic Flood Loss Reduction.*

This symposium addresses the important issue of how to reduce losses from Catastrophic Floods. This demands a major paradigm shift of accepting that complete elimination of flood risk is a difficult, if not impossible, task for many of the large cities in the world that have been historically developed along fertile flood plains large rivers. Once this is accepted, the next step is to access catastrophic flood risks and take mitigation measures that include both structural and non structural issues. Four prominent researchers addressed the following key issues relevant to the theme at the symposium. The thematic areas considered were:

*Historical lessons:* It is indeed a challenge to prepare for a catastrophic flood. Due to the rarity historical experiences of large floods are not necessarily passed from generation to generation. However, it is important to know how people coped in the past and what sustainable social and institutional mechanisms helped reduce losses from catastrophic events. Learning from past and adapting such wisdom for local conditions, is therefore one important agenda in preparing for catastrophic floods.

*Climate dimension:* Recent changes in the climate, especially those associated with global warming, are expected to increase the frequency and magnitude of floods. In addition, changing weather patterns may cause high rainfalls on areas that have not experienced high intensity rainfalls in the past. Most of flood control methods are implemented against expected flood probabilities and therefore rarity of an event, even when the absolute magnitude is small, can be the cause of heavy losses. As such, changes to rainfall patterns may trigger an increase of unexpected events giving rise to a spate of catastrophic floods. Understanding such possible changes in extreme rainfall patterns and mechanisms is another area that needs to be addressed in relation to catastrophic flood loss reduction.

*Urbanization and catchment changes:* The changes to catchment brought about by the urbanization process give rise to flood water quantities and inundation patterns that differ significantly from the past experiences where the level of urbanization was low. Predictions have to be made using numerical simulations based on the actual watershed conditions to assess risk posed by catastrophic floods. Flood forecasting incorporating the vast amount of infrastructure that constitutes present day mega cities is another major challenge that needs to be addressed.

*Community participation:* Once the risk is known, effective use of this knowledge is critical to reduce the losses to life and property. This is a daunting task, especially when the available infrastructure is not sufficient to cope with the flood volumes. Community based activities, mechanisms to participate are very important in this context. Some countries have successfully addressed these issues, and their lessons must be disseminated globally.

The speakers were *Prof. Masaru Morita*, Professor, Shibaura Institute of Technology, *Mr. Koji Yamamoto*, Former Director-General, Japan Meteorological Agency, *Prof. Keiichi Toda*, Professor, Disaster Prevention Research Institute, Kyoto University and *Ms. Lorna P. Victoria*, Director, Center for Disaster Preparedness. The Foundation, Inc, Philippines. The presentations were followed by a panel discussion moderated by Prof. Yutaka Takahashi.

The chapter 1 is based on the presentation of Prof. Morita on historical perspectives. Chapter 2 is based on the presentation Mr. Koji Yamamoto on Climate dimension, Chapter 3 is based on the presentation of Prof. Keiichi Toda and Chapter 4 on Community Participation is based on the presentation of Ms. Lora P. Victoria.

I hope their valuable experiences would help us in 'Preparing for the Unforeseen', so that an *extreme flood* may not become a *catastrophic one*.

I would like to thank Jiwong Ryoo and Sidat Atapattu for helping in various ways in the preparation of this manuscript.

*Srikantha Herath*

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# 1

# INTRODUCTION

It is my pleasure write an introduction to this summary of Public Forum on Catastrophic Flood Risk Reduction. This forum has been organized to highlight a number of issues. It is held on March 23rd , because yesterday was the world water day. Every year March 22nd is declared as the world water day, on which we reflect on a particular theme related to water. The theme selected this year is 'Water and Disasters' and the world Meteorological Organization and the international strategy for disaster reduction are charged with organizing activities for the day. Secondly, March 23rd is declared as the world meteorological day because it is the day WMO was established. 'Weather, Climate and Water in the information age' has been selected as theme for WMO this year. Both these themes are very relevant to the research programme of United Nations University and are addressed by a number of specific projects. Therefore we were very happy to organize an event with our partners to commemorate these events.

The theme 'Water and Disasters' is a very appropriate one because floods are the major cause of death and damage among all natural disasters. According to published disaster statistics, on the average about 60,000 people die each year due to meteorology related disasters. WMO this year has called for a target to reduce this number by one half in 15 years, mainly by technological improvements that would lead to better predictions and warnings together with capacity building and preparedness. If we look at flood hazards that cause the greatest losses, we find rare and extreme events that affect urban areas to be the major cause. Due to rapid urbanization and economic growth, cities in the developing countries have been growing rapidly, often without adequate safety measures against flood disasters. For most cities flood mitigation measures had been an incremental process, where design standards have been increased steadily to cope up with higher and higher flood magnitudes that correspond to rarer flood events. However, at the same time potential risk, both human and economic, had been increasing rapidly, and any catastrophic flood that is well above the design standards could bring about tremendous losses in terms of human casualties as well as economic losses. We need to investigate this vulnerability of major urban areas seriously. Security of urban areas is an important concern because more than half of the world population is concentrated in urban areas and the rest is increasingly becoming dependent on the urban areas for economic as well as cultural growth and development. Sustainability of urban areas is therefore not only important for the urban dwellers, but also for the global community. Safeguarding against an extreme event is one important requirement for ensuring security and sustainability of urban areas.

Flood magnitude and associated frequency varies from country to country. The general strategy adopted in flood control is to prevent high frequency floods through the incremental construction of flood control infrastructure. Once a river basin is capable of handling frequent flood events, agriculture, business as well as industrial development flourish in usually fertile and ideally located flood plains. This economic development on the other hand increase the potential loss due to a flood, requiring ever increasing flood control measures that makes floods rarer. This process inevitably leads to a stalemate situation where further flood control works are too expensive, while a flood which is greater than the design levels would cause catastrophic losses.

At UNU we have been working on this theme and are launching a regional program to address how we can move from a 'fail safe' approach to a more realistic flood control mechanisms that allow 'safe failure'. This summary is derived from the presentations of four eminent speakers on four thematic areas related to catastrophic floods that would contribute to our understanding of this problem.

In addition to commemorating the world water day and world meteorological day, we also wish to highlight UNU's commitment to the success of world conference on Disaster Reduction that would be held next year in Kobe. On behalf of the organizers as well as all of us learning from the outcome of this Forum I wish to thank the four speakers who have kindly accepted our invitation and spent their time and effort in preparing the presentations.

*Hans van Ginkel*

*Rector*

*The United Nations University*

# 2

# HISTORICAL LESSONS IN FLOOD MANAGEMENT

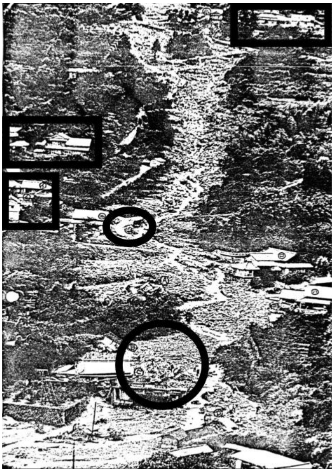
## LEARNING FROM THE HISTORY

Although the number of casualties due to floods is decreasing with improvement of flood control measures, Japan yet suffers severe damages in urban areas from heavy rain falls, demonstrating the limitations of the flood control. As rainfall sometimes exceeds the existing coping capacity of local communities, supplementary measurements are needed to fight against such extreme downpours and reduce resulting damages, which will lead to the overall enhancement of the coping capacity of community in dealing with water related disasters. This chapter focuses on the historical experiences on "role of communities in flood prevention" in Japan.

## 2.1 TRADITIONAL COMMUNITY-BASED FLOOD FIGHTING APPROACHES

It is important to understand how community members have traditionally dealt with floods. One example is the debris flow in Kochi prefecture, occurred in August 1975 (Fig. 1(a)). Circles indicate the heavily damaged areas.

Less damaged houses were old ones indicated by squares. Many of these were main houses, which date back to the Meiji Era, while newer houses which were heavily damaged belonged to the new families (branch families).



(a) A debris flow of Narukawa River in Tosa City


(b) Hake River in Kochi prefecture, 1975

Figure 1. Old and new settlements are affected differently by disasters

As there was a major debris flow disaster in Edo Era, many of those old houses were built considering that experience. It also affected the naming of the "Narukawa River" and its town called "Ishidanomori -*The Forest of Stones and Soil*".

These extreme disasters tend to occur in a cycle of one hundred years. Since traditional flood control was unable to respond effectively to such disasters, they simply built most of the houses in areas geographically less exposed to disasters.

Fig. 1(b) shows the Hake River, which inundated Kochi Prefecture, in 1975. When there is a downpour, the water level increases in the surrounding area. In this case, the increased water would not be able to be discharged to branch rivers. Since there were no pumping facilities at that time, citizens had no other choice, but to build their houses at elevated places. Squares indicate the areas where main family houses were built.

There was a major flood disaster in 1886. This experience has set the standard height of the foundation of those main family houses. Those examples indicate that from early days the disaster-stricken communities have dealt with the catastrophic impact of water related disasters based on the knowledge accumulated from their communities and their experiences which were strongly linked with the flood control. Flood control and flood fighting are two phrases that need clarifications. Conventionally, they have always been linked together. When there is only low-level flood control, it is necessary to fight the flood more severely. This indicates the close connection between flood control and flood fighting. Flood control has always been a part of the administrative activity, while flood fighting is always a voluntary activity of the residents and the community.

When flood control regulations were in a very low level, the farmers formed a community to fight against flood disasters, which was referred to as flood fighting community. After the second world war, the local community itself started to be disbanded and this flood fighting mechanism of the local communities was not effective anymore due to the stricter flood control measures and dilution of organizations.

It is essential to examine what community members were doing to fight against water disasters before the war. There were unique disaster reduction activities in Japan. For example, community members fought with the storm cap on the lavatory tank in order to prevent the filthy water or sewage water from escaping in case of flood. Also, the search stick was a useful device. When all the roads are inundated, you need to have this stick to make sure that you do not fall into a deep hole as you walk through the water. It may be helpful to have elevated warehouses with an emergency boat, in order to store the valuables and evacuate. Community members regularly checked the water and drainage levels. Additionally, they worked together to protect the levee

(a) A heightened warehouse in Ogaki-shi, 1975

(b) A hung boat in a house, 1975

Figure 2. Traditional practices for coping with extreme floods

when the embankment is broken.

All these activities of the community members have been a part of the local culture. Fig. 2(a) shows an elevated warehouse in Ogaki-shi, to store the valuables and protect them in case of floods. In some cases, people actually evacuated to the warehouse. In the area where flood occurs frequently, they had a boat hung from the ceiling to evacuate (Fig. 2(b)).

Wajuu ring embankment is one of the exemplary cases of the community-level effort to mitigate the loss from water-related disasters. Fig. 3 shows its distribution map based upon the Meiji Era. The community area is surrounded with the ring-shaped levee in order to block the massive water inflow in case of floods.

Fig. 4 shows a levee that has been reinforced and protected by the community members. Sandbags were placed to protect the levee, which was a part of the flood fighting mechanism (levee protection).

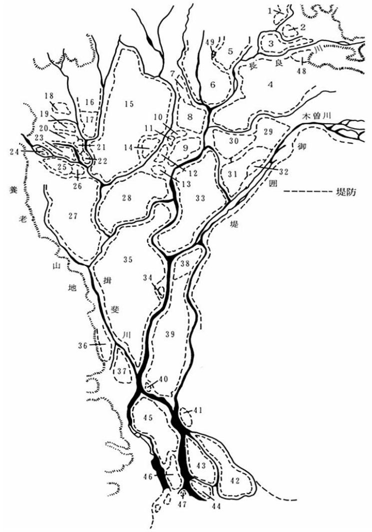



Figure 3. Wajuu ring embankment

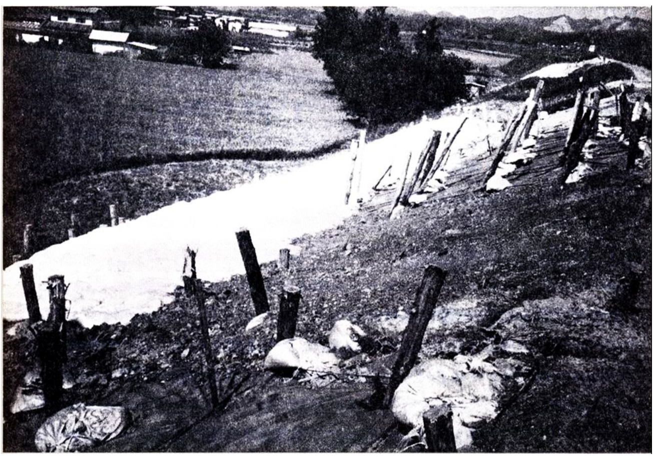


Figure 4. Levee in Abukuma River, 1986


Figure 5. Changes of land usage by urbanization in Soka-shi, Saitama prefecture

Although flood-fighting communities still exist, their activities are slightly different from the past ones. This is to a certain extent due to the Flood Disaster Prevention Law passed in 1949. The current activities are not exactly community-based but merely supplementing what is lacking in the flood control measures. In that sense, flood fighting activities are quite unique and not exactly a natural course of action taken by the residents in the past to protect their own properties and lives.

There are some issues faced by the flood fighting organizations. One of them is the lack of members as present members are getting old. Due to this, overall strength of the organization has weakened and the quality of the flood fighting activities has become very low.

The two pictures indicate the changes between 1964 and 1986 in the city of Soka, Saitama Prefecture (Fig. 5). The land usage was greatly changed, due to urbanization.

Flood fighting activities has changed with the change of community structure. The members of the flood fighting communities were mainly composed of farmers before the war. Information was passed from one generation to another, thus the community members learned from the past experiences of the ancestors. Due to advanced urbanization such information doesn't seem to flow as effectively as it was. A large part of the population has moved outside the community areas, and traditional communities have been destroyed.

## 2.2 REDUCING FLOOD DAMAGE

- Measures in Hardware and Software

| Measures in Hardware | Measures in Software |
|---|---|
| Embankment:Increasing the river flow | Building master plans to regulate land usage |
| Dam to control flood water | Controlling land development |
| Flood way diversion channel | Predicting rainfall and developing the systems to predict floods |
| Retarding basin | Preparing and distributing hazard maps |
| Improving the drainage system | *-Building shelter systems* |
| Flood control basins | *- taking precautionary actions* |
| Drainage pumps | *-taking actions for flood mitigation* |
| *-Facilities for rainwater storage and infiltration technology* | *-Educating about flood disaster* |
| *-Facilities for mitigating damages* | *-Cleaning up the town (Countermeasure for the homeless)* |

Table 1. Measures in hardware and software to mitigate flood damages

There are two aspects in reducing the damages caused by flood disaster. First, it is essential to consider both hardware and software measures (Table 1). There are some community members' voluntary activities (Italic in Table 1). Homeless people cannot be ignored in these measures. For example, homeless people contributed to a large damage when there was a flood in Bangkok, where many homeless people live. Since the number of homeless people seems to be increasing in Japan, we should consider how to protect them as well.

- Hazard Map

Recently, hazard maps are getting popular and are used in many cases. They normally contain the inundation depth as well as the evacuation routes and the destination, such as the public buildings. In some cases, private homes are used as evacuation destinations. An important element in a hazard map is that it indicates the roads of less inundation risk. In addition, it is recommended to insert information about flow speeds.

The hazard map must be based upon past experiences of disaster. Usage of these hazard maps has been increased, yet there are some remaining problems. Although these hazard maps are distributed to residents, people tend to lose them or cannot find it when they need it. Timing also causes problems. At what time the residents should start evacuating and what are the better routes for evacuation? These have not been clearly indicated in the hazard map. When the hazard map designates a risky area, people understand that those areas are risky, yet there may be other areas that can also be affected by the disaster where residents are not aware of. There is a rumor -or prediction- that Tone River is going to flood, and the levee is going to be destroyed. Such information about risks must be provided swiftly to the residents and they should understand that the risks could be everywhere, even in the areas not indicated in the hazard map.

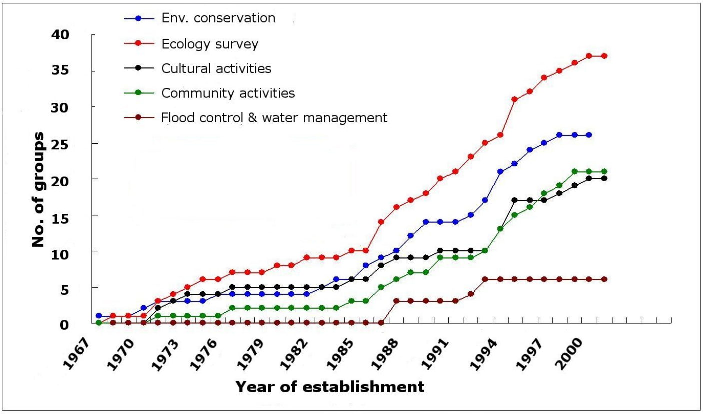



Figure 6. Total number of community group participating local activities in the Tama river basin from 1967 to 2002

- An example of community members' voluntary participation

Obviously, the voluntary participation of the community members is highly important in disaster management. Fig. 6 shows the yearly participation in the Tama River Basin community activities. It indicates the number of groups that are formed to participate in local activities. Many of them are related to environmental activities. The lowest line indicates the change in the total number of groups involved in flood control. With regard to water disaster prevention, community members cannot simply think that it is a part of government activities.

## 2.3 CONCLUSION

Throughout the chapter, the importance of the restoration of the flood-fighting community has been highlighted. Here, restoration does not mean a mere reproduction of the old community but the recreation of the local community activities based on the past experiences as well as the modern-day needs brought by the urbanization process and so forth.

In terms of providing urban information to the residents, a great progress has been made with the emergence of the hazard map. We currently make much progress and improvement in the software side of our efforts, supported by advances of meteorological forecast and prediction technologies of flood. Furthermore, we have advanced information technologies, which are also accessible. There are a lot of possibilities of using information technology in different areas to fight against the flood.

We should consider and design plans to save all people in case of disasters including the elderly. It is also important to provide education to the residents using hazard maps indicating how they should evacuate. The education can be done on a regular basis. Several years ago, residents in Nagoya suffered from a major flood, and then they started the self-learning process for community members.

In short, it is highly recommended that the community members review the traditional flood fighting activities of local communities and understand how the urbanization process has devastated the community structure and weakened their capabilities to cope with disasters. Basically, flood fighting requires both hardware and software aspects. The community members should understand the risk level of the area where they live. With this recognition, they will once again be able to rebuild a flood-fighting community.

# 3

# PREDICTING WEATHER

## TECHNOLOGY ADVANCES AND EXTREME WEATHER TRENDS

This chapter focuses on the weather system, in particular the meteorological occurrences that may cause floods and the sequence of events in the prediction area

The most significant cause of floods is the climate or weather conditions. As a Japanese proverb, "look at the sky" suggests, understanding atmospheric phenomenon is essential for flood mitigation.

Basically, flood mitigation measures are taken based on the past records of heavy and torrential rain. As certain standards are used in the design of infrastructure, it can be assumed that we are ready for large floods, yet it was recently confirmed that localized torrential rains are rapidly increasing, which exceeds the coping capacity of the standard infrastructure and cause serious problems.

Flood fighting is also an important requirement, not only to protect the properties but also for safe evacuation. It is necessary to consider what kind of information is needed to make our decisions. If a typhoon is approaching, we should understand the nature of accompanying high intensity rain. From this viewpoint, the Japan Meteorological Agency (JMA) is trying to improve the accuracy of rainfall predictions and provide climate information to the residents as well as river authorities, or river bureau personnel. However, the information provided by experts is not often understandable for ordinary citizens. Therefore, it is essential to provide visual information for citizens to easily understand the situation without using technical terms.

Some examples of extreme rainfall events are examined to discuss these issues. First is a torrential rain that occurred in the Tokai region in September 2000. The levee of the Shonai River was broken and the water level rose rapidly. The records of precipitation on the 11th and 12th showed 97 millimeters of maximum hourly rainfall even though the recorded previous maximum rainfall in the region was 92 millimeters. The maximum 24 hours rainfall in the past records was 277 millimeters where as it was 534 millimeters on that day.

This extraordinary rainfall occurred due to Typhoon Number 14, which moved very slowly from west to east. The autumn rain front hovered along the Japanese archipelago, which could be seen in the Pacific high pressure system. Furthermore, the typhoon moved along the rim of the pressure system towards Japan. Then a stream of white clouds formed above the Pacific Ocean and developed into cumulonimbus clouds, providing a substantial amount of water to form the torrential rain over twelve to twenty-four hour period.

Analysis of Meteorological Agency and the River Bureau shows that repetition similar to the heavy rainfall in the Tokai Region can be expected. However, the record of the rainfall is uncommon because such rainfall occurs once in 300 years.

Second example is a flood in Yangtze River in China, 1998. It has been the largest since 1954. China has a monsoon season from June to September. Downstream of the Yangtze River through Nanjing area recorded 950 millimeters from June to August and exceeded 1,000 millimeters in total in 1998. Such extraordinary floods have occurred only 9 times for the past thousand years. Surprisingly, most of those floods occurred in the 20th century.

According to the Chinese authorities, the main cause of the floods is not only the climate change but also the population growth and urbanization process which generate sediments near the Yangtze River area.

Third one is a flood in Limpopo River, Mozambique in 2000. The water level was far beyond the peak level. The tropical low pressure system developed in the eastern side leading to torrential rain. Weather prediction had to be stopped as the Mozambique Meteorological Agency was seriously damaged. JMA and the meteorological office in UK discussed the situation and UK took over the weather forecasting system in Mozambique. It was also broadcasted on the CNN News and greatly helped to prevent further damages.

The IPCC vice Chair points out the relationship between climate change and unusual weather conditions. It is very difficult to determine increase of heavy rain and unusual rain patterns. Yet, the IPCC provided the third assessment report in 2001 based on the recent technological capabilities. JMA laboratory and an institute in the University of Tokyo have contributed greatly in compiling this report.

Several unusual phenomena due to global warming are discussed in the report. Increase in temperature of 1.4 to 5.8 degrees in the next hundred years would increase rainfall in winter and temperature of sea surface in the northern hemisphere and Antarctica. Raised sea level will not merely decrease the existing land area but also change the river flow of the downstream area. Therefore it is necessary to change the flood situation, focusing on this phenomenon.

In addition, extreme rainfall conditions that frequently occurred in the northern hemisphere, in particular mid to high latitudes, in the latter half of the 20th century, will repeat in the 21st century. Typhoons also will change considerably in terms of increasing wind speed and rainfall. As a result, drought in certain areas may increase. IPCC reports that the atmosphere may change due to global warming. Since it is not clear when these changes will occur, preparing for possible extreme rain condition become extremely important.

In Japan, some rainfall events surpassed 100 millimeters per hour in the latter half of the past decade and these events have increased in frequency. It is not clear whether the phenomenon is the result of global warming or natural variance. Additionally, the heat island phenomenon due to urbanization is also a critical factor in the increase of heavy rain.

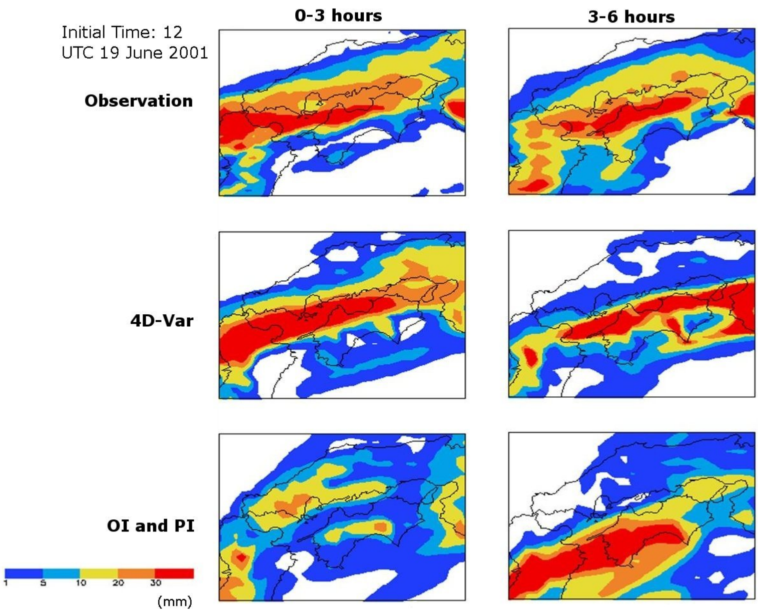



Figure 7. Impact of 4D-Var on Rainfall Forecasts

Another issue in Japan is that its drainage capability may not be sufficient for heavy rains and as a result the underground infrastructure can be severely affected. Thus, it is necessary to consider disaster prevention in underground structures as well.

One of the crucial measures to prevent flood disasters is to improve the accuracy of weather prediction and forecasting systems. The current forecasting system utilizes numerical prediction. Flood prediction is based on MS and Meso measurement, which alerts to scale phenomenon, cumulonimbus clouds, rain fronts, etc. Mesoscale Model (MSM) are applied to the midrange of weather patterns to provide weather forecasts.

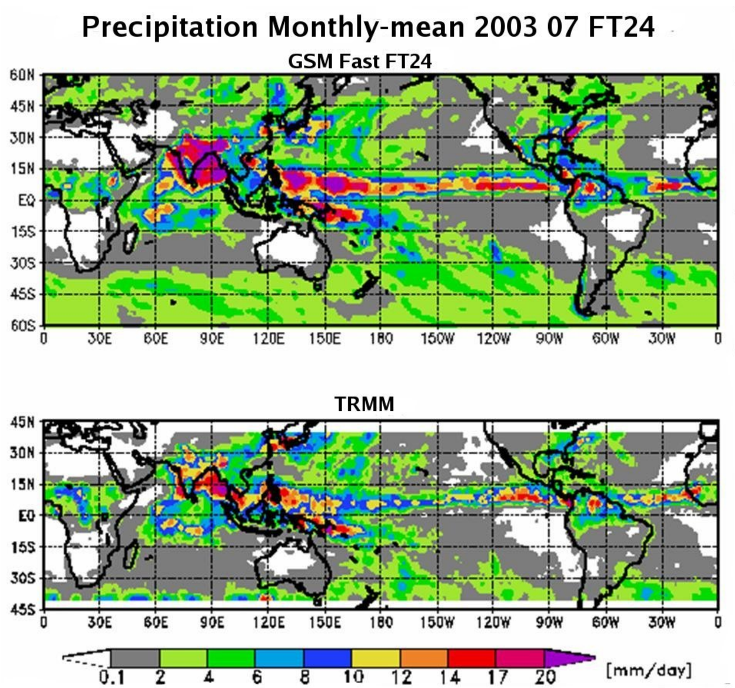



Figure 8. Global Rainfall Forecasts from GSM and TRMM

Fig. 7 shows the impact of 4D-var on rainfall forecast. Comparison of the actual observation against the predictions made using the two different technologies shows that 4D-Var, the new technology, predicts an accurate situation.

Fig. 8 shows GSM and TRMM- the Tropical Rainfall Measuring Mission satellite, based on Jackson's observation forecast methods. Our model looks at the strength of rain, rather overestimating this, but the rain band, overall, is reproduced well. The numerical system will be expanded for prediction of rain in other Asian countries. In the future, we are hoping to provide information through the Meteorological Agency Network and at the same time through Internet.

This data would be very helpful for many countries, particularly for the developing countries in terms of efficiency, as utilizing Internet does not need building up new infrastructure for information dissemination. The data will also provide essential information to prevent floods and other disasters in these areas.

More importantly, water issues are central not only to floods but also in water shortage situations, which has serious impacts on our daily lives as well as in economic activities. Meteorological agencies and space agencies around the world should work together and present a concrete apparatus for international cooperation so that they can integrate various methodologies and sources of information from different countries and build a more accurate information system.

It is important to obtain the information on a real time basis and develop an alert system for any possible floods. Such efforts have been made through an international project. There is a network system in Japan developed by JAXXA, the Japanese Space Agency, which cooperates with the US NASA and the space agencies in Europe. A satellite having radar orbits the earth every three hours and monitors rainfall situations. This project will be launched in 2007. While JAXXA will collect the satellite data and provide it to the JMA and the River Bureau, JMA will input the data to a numerical prediction model. It is expected that this project will vastly improve the accuracy of prediction.

The prediction will also be provided to the Weather Bureau's International Flood Network. By doing so, the River Bureau can compare the prediction as well as GPM data and provide warnings as necessary. Japan is utilizing these technologies and has a great role to play in contributing in terms of information dissemination in the Asian region.

One question is how we can jointly improve the flood mitigation. Led by the same minister, the River Bureau and the JMA can closely cooperate and exchange weather information. This enables both organizations to monitor the real situation everywhere and provide warning. In addition, it is also expected that they will be able to provide prediction about how the water level may change in certain areas. This is a unique cooperation style because the organization usually observes only specific situations. In other words, the river authorities are looking at the dams and the water levels, while the meteorological agencies are looking at the sky, climate and weather. An accurate picture of the whole Japan can be produced if the radar picture from the Meteorological Agency and the radar picture provided by the River Bureau are overlaid. Data are collected by monitoring systems every ten minutes. Thus, we can also understand where flood is occurring and estimate how flood may spread in a region.

In conclusion, we may experience record torrential rain and flood damages in the current Century of Water. Yet, if we can utilize the knowledge that we have accumulated in Japan and provide assistance, there is a great role that Japan, the River Bureau, and the JMA can play. If these two different organizations can cooperate, we will be able to provide accurate information to the general public and heighten the awareness of the public.

The River Bureau and the JMA are currently trying to provide an alert system for danger areas where there is a possibility of landslides. We will start using this new system on a trial basis. Since flood control is a very important issue, consistent efforts are necessary for a better understanding of the nature of the flood disasters and its relation to climate conditions.

# 4

# URBAN FLOOD AND ITS PREDICTION

This chapter mainly discusses the current technology for disaster prediction and the best practices of applying advanced prediction technologies in real life.

## 4.1 EXAMPLES OF RECENT URBAN FLOOD DISASTERS

Some examples of recent urban flood disasters are introduced here, followed by an analysis of a case study involving underground inundation.

### 4.1.1 *Flood in Fukuoka prefecture, Japan*

In June 1999, Fukuoka suffered from an urban flood. Inundation occurred in the center of the city and the runoff water seeped into underground levels (Fig. 9). The maximum rainfall was recorded as 77 millimeters per hour.

On July 19 2003, another flood disaster took place in the same area of the central city. This time, hourly maximum rainfall of the Fukuoka city was much less than 77 millimeters and the total rainfall was approximately 120 millimeters, but the Basin of Mikasa River, the upstream area in particular, received 99 millimeters of hourly maximum rainfall, which seemed to have

Figure 9. Flood disaster in June 1999 in Fukuoka prefecture, Japan

flowed into Fukuoka city. Thus, it is necessary to examine the whole basin area in this case since the cause of the flood was not created by the rainfall in the city.

### 4.1.2 *Flood in Nagoya, Japan*

An urban flood occurred in Nagoya city in September 2000 (Fig. 10). The total rainfall was more than 500 millimeters. The flood broke the levee of the Sinkawa River and water started to flow into the town. Moreover, debris free turbid water observed in the city means that the inundation occurred mainly due to poor drainage.

Due to heavy inundation, a large number of citizens had to be evacuated. At the same time, the electricity had a serious problem. Express trains (Shinkansen) were stopped and many subway stations inundated. People, therefore, could not use such public services during the disaster.

Figure 10. Urban Flood in Nagoya City in 2000

### 4.1.3 *Flood in Europe, 2002*

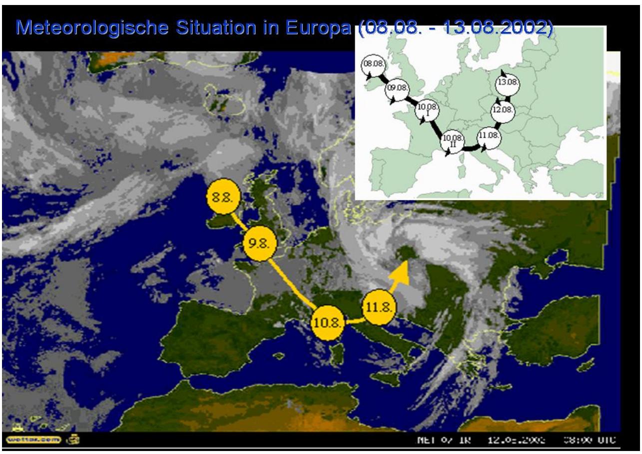



Figure 11. Slow movement of the center of low atmospheric pressure

In 2002, a major flood occurred in Europe. The low pressure moved very slowly and started to stay above Europe for quite a long time (Fig. 11). Especially, France, Czech Republic and Germany suffered from torrential rainfall.

#### 4.1.3.1 *Flood Inundation in Prague*

(a) Karlin District in Prague

(b) Basement condition in Karlin

(c) Destroyed building in Karkin District, Prague


(d) The trace of flood inundation water at Olympic Hotel

Figure 12. Flood damage in Prague, 2002

There was an overflow of the Vltava River, which caused inundation and very slow basin filtration. The old town had been protected from the flood disaster, due to meandering of the river. During this urban flood in 2002, there was much overflow along the river, especially in the area around the Japanese Embassy. Fig. 12 (a), (b), and (c) show the damages from the flood.

An inundation depth of two-meters was observed along the winding line of the Vltava River (Fig. 12 (a)). In addition, the basements of the warehouses were completely destroyed (Fig. 12 (b)). Fig. 12 (c) and 12 (d) illustrate the destruction caused by flood inundation. Olympic Hotel located near the river was flooded and the line created by the inundation remained at a height of two-meters.

#### 4.1.3.2 *Flood Inundation in Dresden, Germany*

There were three floods in August 2002 in Dresden, Germany. Two of them were the overflow of tributary of the Elbe River, and the last one occurred due to rising of ground water level. The embankment and levee were broken from the first flood.

The other two occasions of the flood disasters were due to different mechanisms. Some areas were damaged by the Elbe River inundation and many buildings were submerged. Groundwater level started to rise within a short period of time (Fig. 13 (b)).

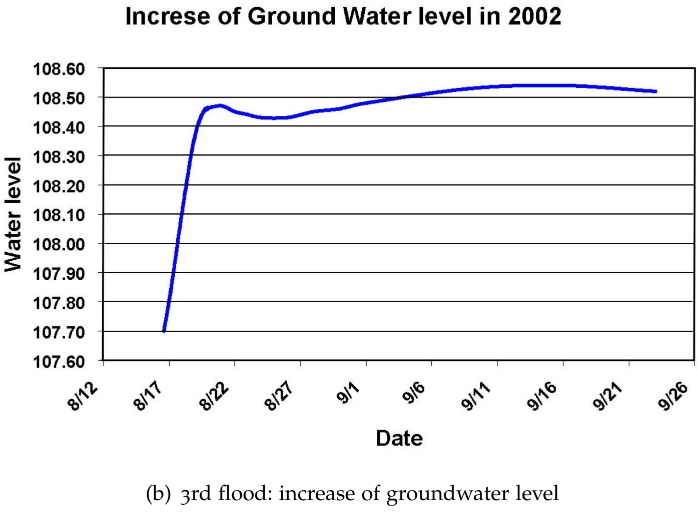
Many disastrous floods occurred in Japan, Korea, and other Asian countries as well. This clearly indicates that no country can escape from water related disasters.

## 4.2 FLOOD REVIEWS

One of the main causes of flooding is heavy rainfall. Infrastructure damage such as disruption of transportation services is the major issue caused by urban floods. There are direct impacts as well as indirect damage, which require long standing restoration efforts.

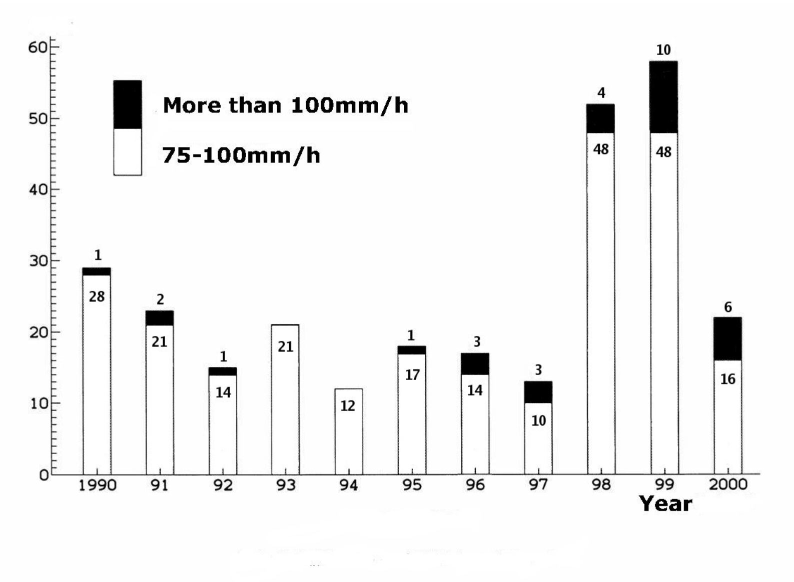
It is clear that because of the higher frequency of short duration rain falls, flash flooding can occur frequently in urban areas(Fig. 14 (a)). In addition, rapid urbanization could be one of the causes

(a) Inundation condition in the Central area of Dresden




(b) 3rd flood: increase of groundwater level

Figure 13. Flood damage in Dresden, 2002




(a) Frequent heavy rainfall


(b) Vulnerability to flood in urban area-increase due to rapid runoff resulting from urbanization

Figure 14. Higher frequency of short duration rainfall cause flash flooding in urban areas

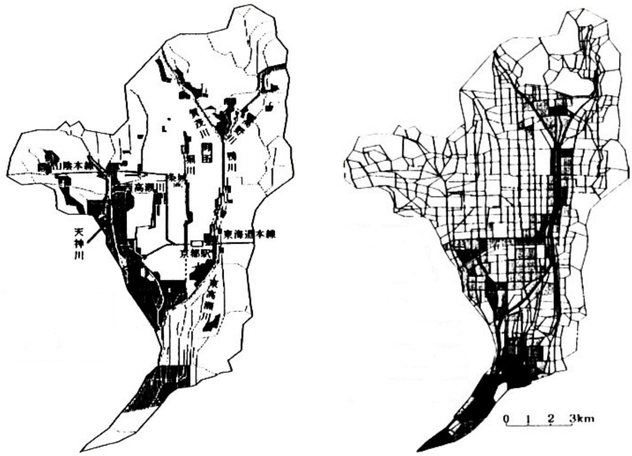
for flood as rain water could seep into forests and mountain lands in the past, where as with the paved ground surface in urban areas, rain water cannot seep into the ground. (Fig. 14 (b) ). Therefore the water flow reaches its peak in a very short period of time. In particular, rainwater in relatively flatland areas could not be easily discharged into the river. Thus, it becomes difficult to use drainage pumps as the river water rises to danger levels. The pumping mechanisms will not effectively function without appropriate advanced coordination to use it.

## 4.3 PREVENTION OF URBAN FLOOD

The most common cause of urban flood is not the levee breakage but poor drainage. Therefore it is necessary to examine the possible preventive actions to reduce the urban flood disasters. Above all, we should learn from the past painful experiences. Although calculations and simulations are important in predicting the possible inundation areas, it is clear that, areas that suffered from past flood are more vulnerable.

This highlights the necessity of being able to predict the size of the urban flood disasters and designing appropriate measures. We also need to combine different approaches to come up with a comprehensive and integrated methodology.

To ensure safety of urban environment, it is important to consider the river system surrounding the center of the city. Localized solutions do not effectively control floods. First of all, the water discharging from the mountainous area would flow into the river system. The discharge from urban areas will be drained through the sewerage system.




(a) Inundation record of Kyoto flood in 1935

(b) Computational results

Figure 15. Inundation simulation of Kyoto city

Therefore when flood disasters in the urban environment are considered, it is necessary to take into account the rainwater runoff coming in, as well as the increase of city drainage level. All these must be considered as possible causes of the flood in the urban environment. In 1935, there was a major flood caused by heavy rainfall in Kyoto. What might happen if a same size of flood occurs in Kyoto today? As mentioned earlier, it is necessary to consider whole catchment area, including the surrounding area of Kyoto city and how rainfall runoff might take place, as well as the discharge from drainage system.

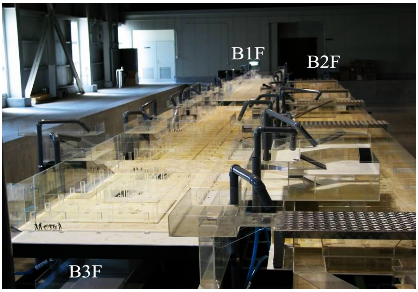
In 1935 the rainfall was approximately 300 millimeters. A simulation study with same rainfall as input across the Kamo River basin was conducted to analyze what may happen today. Fig. 15 (b) shows the computed results.

The impact of the possible flood can be predicted at least to a certain extent, by establishing a physical model. A scale model of the actual underground space was constructed for the analysis of Oike Underground Commercial Shopping Center area. The model was one-thirtieth of the actual size of the shopping mall. The Experiment was conducted under the assumption that 100 tons of water flow from Kamo River, which may occur once in 80 to 100 years. Our model demonstrated that 35 tons out of the 100 tons would flow into the underground area. In the eastern side stores in the third, second level at point A or point C shown in Fig. 16 (b), the water level will rapidly reach up to 50 centimeters within 20 minutes. In the case of the third underground level, due to the limited space 50 to 100 centimeters of water will be accumulated within five or ten minutes. The result shows that certain areas are in high risk if water flows into the underground area.

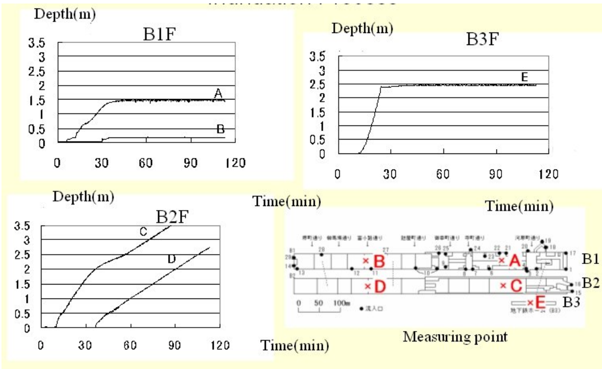
Although the water in a subway or underground system will flow out with time, water in certain places in the underground station will flow to the next station due to elevation difference. Also the stairway area may cause danger for evacuating people in an underground shopping area.

According to Fig. 16 (c) which indicates "evacuation possibility at stairs", people in the upper right hand side will not be able to evacuate. Only up to 30 centimeters of water level allows use of the staircases for evacuation and the stairways will be inundated when the water level becomes 50 cm. Delay in evacuation may cause a great disaster.

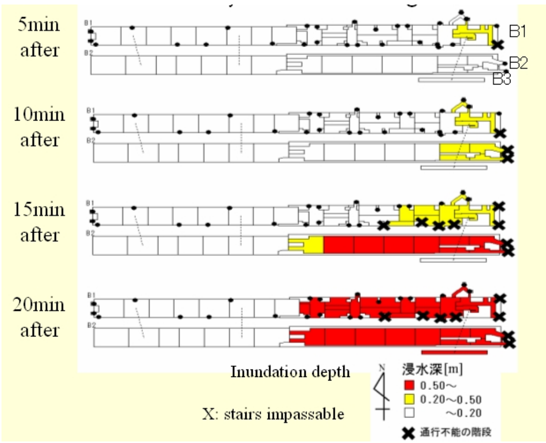
This experiment clearly shows the urban underground shopping malls are in extreme danger in unexpected natural disasters. Particularly, the underground area located near the source of water flow needs a thoroughgoing analysis to form countermeasures. Therefore, it is very significant to study the inundation flow behavior in underground space from hydraulic and disaster preventive aspects.




(a) hydraulic model




(b) inundation process




(c) Evacuation possibility at Oike underground Mall-after 5, 10, 15 and 20 minutes respectively

Figure 16. Model study of underground space inundation

A robust simulation model has been developed based on "Tank Model" which is a conceptual mathematical model that can simulate rainfall- runoff process. This model is simple and the amount of data required is less, compared to more complex models that simulate the hydrological processes. The model was applied to Umeda underground space in Osaka and inundation flow behavior was examined. There are about five subways, as well as JR lines in Umeda district passing through this area.

The assumption made in this simulation is that 60 tons of water runs in from the north, then another 60 tons of water runs in from the south, and analysis was done based on mathematical formulas. Two different inflow cases were considered(fig. 17).

In the first case, water enters from the northern side, and it spreads from the Higashiumeda Station all the way for about a stretch of ten kilometers(fig.18) through the Tanimachi subway. If the water runs in from the south as assumed in the second case, it would not spread over a very wide area, but will cause damage to a different railway line; JR Tozai Line.

As described above, complex underground flood situations can be predicted based on these models. Since underground malls and subways have not been designed for future flooding or inundation, it is necessary to examine these models and their results carefully.

All the related elements such as drainage system, direction of the river flow, and storage facilities in the underground area should be incorporated in planning of countermeasures to come up with a comprehensive solution for flooding in urban areas.

Neya River Basin- in the eastern part of Osaka is an example of improper flood control planning. It is a low lying area surrounded by Ikoma Mountains. The area was developed in the post-World War II era, and many incidents of flooding and inundation have occurred in this area. By observing the pattern of

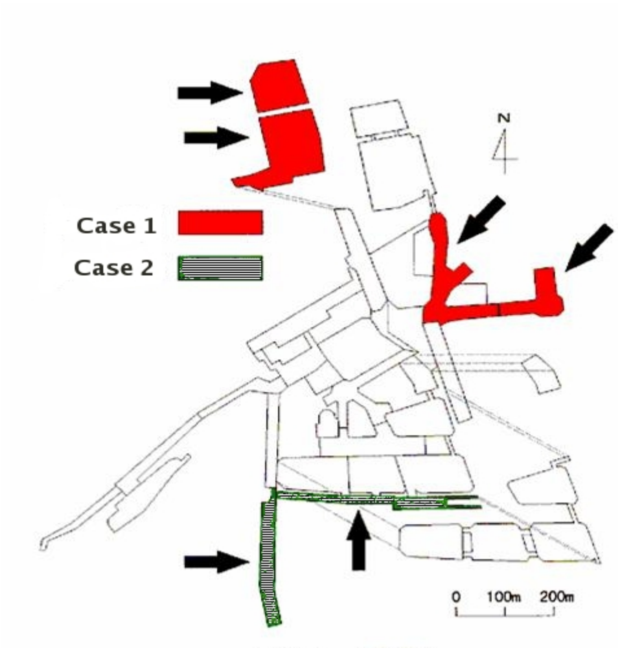



Figure 17. Assumed inflow directions for the two cases considered in the simulation

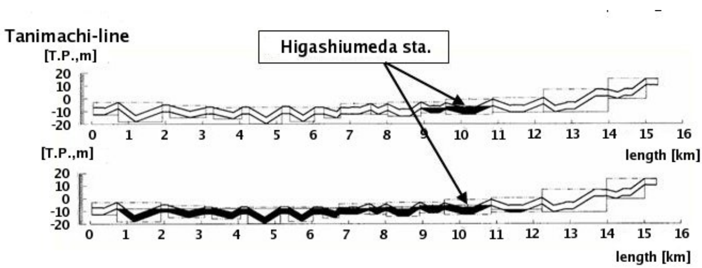



Figure 18. Inundation of subway lines

discharge flowing into the river it became obvious that rainfall will flow to low lying areas, and run into the drainage system. The cause of inundation is the overflow from the drainage system. Thus, by analysis of heavy rain, drainage, and overflow, combined in the calculation, it is possible to simulate flooding in areas that previously experienced inundation.

In Osaka, there are plans to create discharge facilities within the next fifteen years and also to create river basin disposal storage areas in order to control inundation and floods. What will happen when those measures are completed?

If we have a discharge facility and storage facilities as planned, a '99 level heavy rain would be manageable, but if we have another rainfall similar to 1957, which was the heaviest in the past records, the damage may have been reduced but still not under full control. In short, it is necessary to improve discharge and storage facilities and provide effective evacuation routes and land usage guidelines as well.

What needs to be done in the future? First of all, it is necessary to understand the nature of our urban environment. For this end, it is necessary to improve urban area flood prediction methodologies. The role of the government is critical to carry out effective measures. Also, we need to reinforce the quantitative evaluation of urban flood controls, to assess their effectiveness.

# 5

# COMMUNITY PARTICIPATION IN FLOOD LOSS REDUCTION

Despite recent advancements in science and technology, disaster frequency and losses are increasing. Disaster threats compel governments, NGOs and communities to take community-based approaches to reduce disaster risks and prepare for risk mitigation. From the initial experiences highlighting the benefits of community-based disaster risk reduction, now there is a general recognition that community participation in disaster management is essential to reduce disaster frequency and loss. To encourage better understanding of the community participation in flood loss reduction, this chapter explores three components; the framework of the community based disaster risk reduction, case stories of the community involvement and lastly the lessons learned in regional workshops on community-based approaches for disaster risk reduction.

## 5.1 KEY FEATURES OF COMMUNITY BASED DISASTER REDUCTION

In Philippines, "Community-Based Disaster Preparedness and Mitigation" is called "CBDPMIT". There are five key features and a goal to be considered. First key feature is community participation is essential. Second, community-based disaster management builds on and strengthens community capacity, which has traditions of involvement in disaster management or having public safety for their families and communities. Third, disaster risks and vulnerabilities are rituals. Forth, it is necessary to emphasize proactive responses of disaster prevention, mitigation and preparedness, which are beyond the level of emergency management. Finally, the most important feature is multi-stakeholder, multi-sector, multi-disciplinary and multi-level disaster risk management, or what we call "inter-sectoral inter-level disaster management". Yet, the first priority is always the vulnerability. It is also essential to integrate disaster management into the development planning processes, since mitigation and prevention offer the best opportunities. Primary goal of these key features is to transform the vulnerable communities into safe, disaster-resilient or "disaster-resistant"- communities.

There are 8 levels of participation, and meaningful participation of the community members are placed in the higher levels of six, seven, and eight where people participate in decision making (Table. 2). They not only are informed, educated or consulted, but also actively participate in designing risk reduction measures so that they can own the measures. Then, we will apply community based disaster preparedness, mitigation and good practices in community development in both rural and urban levels, and community based natural resource management.

After creating the framework, a question appears; what is the content of community based disaster risk reduction? They are mainly prevention, mitigation and preparedness. We may be able to prevent a hazard from occurring through application of science and technology, yet when that is not possible, we will try to have protective measures.

If the man in Fig. 19 has a shelter, he will not be hurt by the rock when it falls. However, when one cannot have a shelter due to some reasons such as the price tag of science and technology or high cost, at community level, preparedness can be always an

| | |
|---|---|
| 8 | Citizen Control |
| 7 | Delegated Power |
| 6 | Partnership |
| 5 | Placation |
| 4 | Consultation |
| 3 | Information |
| 2 | Therapy |
| 1 | Manipulation |

Table 2. Levels of Participation

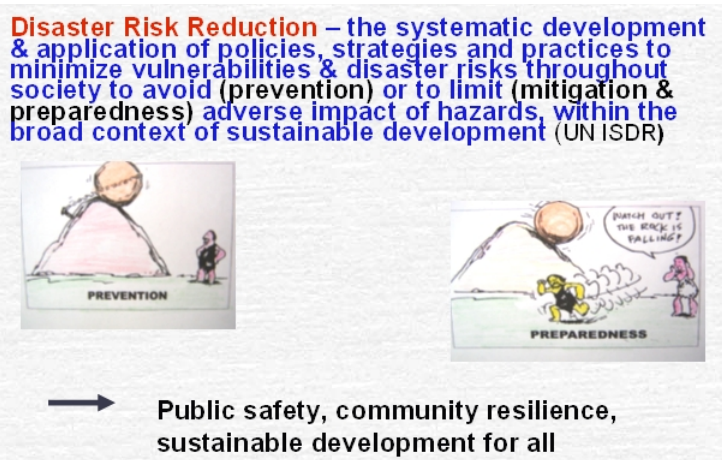



Figure 19. Managing risk

option, e.g. running to a safe place or evacuation. All of them are included in the framework of sustainable development.

## 5.2 STEPS TO REDUCE DISASTER RISKS

There are some steps involved in community based disaster risk reduction. First is community selection. Next is to understand the community. Usually it involves two stages; first, make a general profile of the community and then establish rapport with the community. Third is participatory risk assessment, which focuses on the hazards, vulnerability and capacity situation of the community. From this risk analysis, we can identify appropriate risk reduction measures in participatory planning. Next is to build an organization to implement disaster risk reduction plan. On the sixth, community managed implementation follows the planning. Monitoring and evaluation is next in order to provide regular feedback to the system and also to improve the indicators for public safety and development. Moreover, through this monitoring and evaluation process, the community can draw lessons from its own experiences and share them with other communities in the form of not only case studies that are usually academic, but also case stories.

The risk reduction process usually starts with different perceptions of "risk". One may see a canoe, a big fish, a boy, and maybe a sack of rice in Fig. 20. Others may realize some trees and grass and some birds. It is natural for community members to have different perspectives on risk due to the differences in age, gender, social classes, economic status, and educational background. Additionally, outsiders and community members may have different perceptions of their risk.

The participatory risk assessment unites the community to have a common understanding of their disaster situation or their disaster

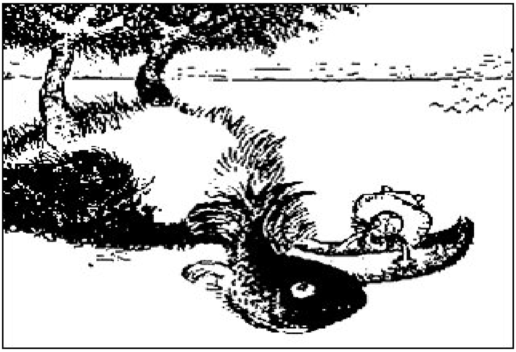


Figure 20. Difference of view points

risk, by answering the followings; the hazard exposure of the community, vulnerable conditions they face, cause of their vulnerabilities and their capacities including the traditional methods of coping with disasters and hazards.

The basis for participatory planning unites the community in commitment and actions to reduce disaster risk, vulnerabilities and to increase capacities. The risk reduction measures identified at the community level can range from structural measures or hard measures to non-structural measures. Structural measures cover embankments, drainage systems, and hydraulic works, while non-structural measures at the community level can cover safety measures for preventive health, ensuring a potable water supply at the community level, legislation, insurance, economic mitigation including strengthening livelihood, policy study, and advocacy for environmental protection and management. Preparedness measures at the community level contain a wide range of training and educational activities, simulation exercises and drills for early warning system. At first, hazard monitoring would be conducted, and then an early warning system would be worked out. It is also necessary to have public awareness activities, strengthen the organization, arrange inter-institution, specifically prepare for emergency, and look into logistics and stockpiles for evacuation.

## 5.3 REQUISITES IN COMMUNITY BASED DISASTER RISK MANAGEMENT

Through experiences, there are several requisites in community based disaster risk management such as having a counter-disaster plan or a community counter-disaster plan (i.e., a community based disaster management plan or a community based disaster risk reduction plan), building capability in community based disaster management. Due to the training for capacity building, public awareness would be developed. Formation and strengthening of disaster response organization and volunteers from the community to engage in plan implementation and mobilizing the community members are the other requisites.

Another requisite is partnerships in disaster risk reduction. As vulnerabilities are not usually within the control of the communities, communities alone cannot reduce their risk. Partnerships are currently forged among communities, local governments, NGOs, business groups, and other stakeholders for a multidisciplinary and multilevel disaster management approach. It is also important to make a framework so as to integrate disaster risk reduction, and then develop planning system. To sum up, flood control should be linked to urban management or development.

## 5.4 PRACTICES IN COMMUNITY BASED DISASTER MANAGEMENT

Specifically community based flood risk reduction, in the Philippines, Cambodia, Bangladesh, India, and some countries in the south Pacific islands will be introduced here.

### 5.4.1 *Practices in the Philippines*

The Citizen's Disaster Response Center, organized in 1984, is implementing citizenry based and development oriented disaster response. It also involves in vulnerability reduction under close connection with communities through overall capability building, improving preparedness by hazard and vulnerability mapping, formulating counter-disaster plans, establishing grassroots level and community disaster response organizations, and conducting evacuation drills.

Mitigation depends on strength of livelihood and community health, advocacy, and small structural measures. In urban poor communities, i.e. primary cities or mega-cities in developing countries, people improve mobility during flood situations by putting up the risk boats so that they can easily go in and out of the community, especially to commute to and from work.

Fig. 21 shows several photos of community activities. The left one is a simulation for early warning and evacuation in the community. The picture in the middle is the boat for increased mobility. The upper right shows the community members discussing alternative livelihood schemes for women as a part of strengthening livelihood activities. The other pictures at the top indicate community health activities to ensure that communities can stay robust and protect themselves upon disaster situations. The last one at the bottom is about an advocacy campaign.


Figure 21. Community activities

"People Bonded Together" is a community organization, where people gather and learn how to live with floods through community preparedness and emergency services. Following the disaster preparedness seminar in 1997, community members formed a disaster response committee composed of thirty-three members and formulated a counter-disaster plan to protect their community from damages due to regular flooding. Three disaster management teams were organized and emergency and evacuation plans were detailed. Three fiberglass boats were fabricated using local knowledge, expertise, and labor, and river rescue maneuvers were practiced as well.

Two months after the disaster preparedness seminar, a typhoon hit the community. Although several houses were swept away by floodwater, no deaths were recorded and many people were able to save their belongings. Through this experience, people can be brought to safety when a typhoon or flood occurs in the area because of the flood level monitoring operated by the disaster response committee, early warning system, evacuation, rescue operations and relief assistance activities.

Their efforts toward disaster preparedness activities have been widely appreciated. The neighboring communities began to consult them for initiating their own disaster preparedness activities. Although Boclatado has honed the skills of community disaster preparedness for flooding, disaster mitigation is still quite a complex undertaking. The recent strengthening by the government of a portion of the river across the community has resulted in landslides in the river portion. Boclatado now undertakes sandbagging to reinforce the river embankment at the site of their community.

The Philippine National Red Cross also undertakes an integrated community based disaster preparedness program. From 1994 to 2001, they have formed sixty-four voluntary disaster action teams, fostering disaster action plans at community level. Several hundreds mitigation measures have been implemented in the Red

Cross areas. The integrated community-based disaster preparedness program of the Red Cross provides intensive training for developing the disaster action teams of the village, which conduct the risk assessment in local disaster action planning with community members. The program uses GIS with other participatory tools to prepare hazard and resource maps. The digitized maps prepared by the Red Cross headquarters are turned over to the municipal government and contribute to improve land use planning.

In the village of Maassen in Gasanpalowan, the volunteer guide of disaster action team mobilized the community for constructing a hanging bridge to be used during flood situations. The bridge will allow people to access village center and children to continue schooling. A nearby village of Real constructed drainage canals in the center area of the community based on the volunteer guide. The Red Cross provided the materials, the local government the technical engineering support in the designs, and the community the labor to construct these mitigation solutions.

A national conference on community based disaster management was held in January 2003, in Philippine. At the conference, the key benefits derived from community based disaster management implementations, such as community preparedness, zero casualties, effective response, self-help, optimum utilization of resources, community solidarity, strengthened community organizations and enhanced coordination and networking called for the widespread replication of community based disaster management all over the Philippines.

### 5.4.2 *Practices in Cambodia*

Cambodia, especially two major watersheds: The Mekong River and the Tonle Sep River, is often affected by flood. Nevertheless, disaster management has not been activated as its tradition of solidarity and trust has been seriously disturbed by the internal upheaval and war for three decades. Usually, family members do not think that they can rely on and have any responsibility for other families.

As Cambodia is one of the least developed countries in Asia, its community based flood mitigation and preparedness project has been jointly implemented by the Asian Urban Disaster Mitigation Program of the Asian Disaster Preparedness Center and the Cambodian Red Cross since 1998. The project also include some agencies, the International Federation of Red Cross, Red Crescent Societies, and twenty-three villages in three districts in the provinces of Kampong Cham, Khandal and Prey Veng.

The solutions of mitigation generally focused on water control structures for livelihood to improve evacuation methods by raising road levels and/or constructing small bridges. Next year of completing the project, replication of mitigation solutions in project areas and in communities outside of the project have been implemented. A key success factor was the setting up of the disaster management committee from the community members.

One villager in the project area, Mr. Benorn, said, "As we completed our project, our community became closer. This is something I have not seen in a long time." Also, these projects contributed restoring the solidarity of the community.

Through study tours, the Vietnamese National Red Cross has also now incorporated lessons learned in flood management in Cambodia to the Vietnam situation.

In India, after the 1999 super cyclone that hit the coastal areas of Bhuhaneswar, leaving behind ten thousand deaths and extensive damages to houses, infrastructure, livestock, crops and environment due to flooding, the Orissa State Disaster Mitigation

Authority implemented the BYLOT community based disaster preparedness program, with technical and funding assistance from the United Nations development program. From March 2001 to September 2002, 1,603 villages within ten blocks in seven coastal districts developed community contingency plans after participatory assessment and hazard mapping. From the cluster of villages at the block level, disaster management committees were trained to organize and systematize disaster response at the local level. Various task forces were organized and trained to manage early warning, search and rescue, first aid and medical assistance, shelter management -especially to be used during catastrophic floods-damage assessment, relief and psycho-social counseling.

As the program had been very successful in implementing disaster risk management on the agenda of local government, and its institutions, the model is now actively promoted in India by integrating it into the development planning system.

During a "Lessons Learned" workshop, after the Orissa floods in 2001, many recommendations and suggestions were made for the immediate development of disaster management plans, including hazard and vulnerability mapping with enhanced community participation, and the implementation of community based drainage plans, combined with scientific input but emphasizing local ownership and management of the flood control measures, and they are being implemented.

In Bangladesh, one of the most disaster prone countries in the world, cyclones, floods, storm surge, tornado, drought and famine strike with regularity and intensity. To reduce vulnerability of flood prone communities, CARE Bangladesh, together with the demonstration municipalities of Tongi and Gaibandha, has implemented the Bangladesh Urban Disaster Mitigation Project since 2000. Mitigation solutions implemented at the household and community level included to raise homesteads, tube wells, roads, community place, school grounds and cluster villages. New dams, drainage canals, roads, tube wells and fillings were also constructed and installed above flood level.

The importance of awareness-raising among community groups and other sectors was also emphasized. Posters, billboards, signboards on rickshaws, newsletters and bulletins as well as actual demonstrations, cultural events, idea sharing workshops and cross visits among the various forms and venues are used.

Risk and resources mapping done at community level are also available. These are not very quantitative maps, but rather descriptive, designating vulnerable areas and evacuation routes to safe places.

As more and more countries are now recognizing the benefits of community participation in disaster preparedness and mitigation, they are much interested in building local capacities. In the Pacific islands, the Pacific community based Disaster Preparedness and Awareness Training Project is being implemented by World Vision, Pacific Development Group and Center of Disaster Preparedness Foundation in Philippines. The target comprises of 120 villages in Papua New Guinea, Vanuatu and Solomon Islands to develop community based disaster preparedness capability building activities.

What are the benefits of community based disaster preparedness and mitigation? During the "Lessons Learned" workshop in Bali, where also the Bangladesh Urban Disaster Mitigation Program and the Cambodia Flood Mitigation Project participated, the following key benefits were identified. A wide range of innovative and doable preparedness and mitigation solutions are suggested through community participation. Community involvement leads to ownership, commitment, individual and collective actions to have safety in the community. Disaster preparedness and mitigation is cost effective. It strengthens social cohesion and cooperation. It builds confidence among the individuals, households in communities to engage in disaster management, and notably, in development. Case stories clearly speak that community based disaster management is effective, and this leads to replication in other communities and increased demand in general for community based disaster risk and reduction.

In this sense, our remaining task is to involve and support communities developing preparedness and mitigation solutions. Usually, participatory tools that enhance community participation can be used, such as hazard and vulnerability mapping, time lines or storybook profiles, seasonal calendars, visualization and focus group discussions in communities. We should not underestimate them, nor underestimate their capacity. We should carry our actions and commitment in building a culture of safety ensuring development for all. It may take a long time, yet we should remain persistent to reach our goal.