Roadmap toward Effective Flood hazard Mapping in China

Concluding Report For

JICA region-focused training course on flood hazard mapping

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1. The role of flood hazard map to mitigate flood damages in China

1.1 Current flood situation in China

China is endowed with about 50,000 rivers, including 1,600 rivers with water basin larger than 1,000 km^2 each. The topography of China is characterized by high west part and low east part, gradually descending in elevation from the west towards the east to form three steps. The main river systems consist of seven major rivers, the Yangtze, Yellow, Pearl, Haihe, Huaihe, Liaohe and Songhua rivers. Most rivers, including seven major rivers, flow from west to east, directly or indirectly emptying into the Pacific Ocean. And the total annual average runoff is about 2,800 billion m^3.

China is subject to strong monsoon climate and most of the areas are under the impacts of the southeastern and southwestern monsoons. The average annual precipitation in China is 648 mm. About 70% of annual rainfall is concentrated in the flood season lasting from June to September in most area. The floods have the characteristic of high peak discharge and great amount of flood volume. The water volume of one large flood may account for the annual runoff of the river. The extremely uneven temporal and spatial distribution of precipitation and river runoff constitute the fundamental cause of frequent floods and waterlogging in flood season.

Floods occurred frequently in China. According to statistics, in the past two thousand years, nearly one thousand comparable large floods have occurred altogether, and one flood disaster occurred in two years in average. During the 1990s, six out of 10 years witnessed major floods taking place in the major river basins. In some areas, floods occur every year. On average, there are seven typhoons that land on the mainland of China every year. Torrential rains also cause mudflow and landslide problems. The total flood-prone areas are about 1.06 million km^2, nearly 11 percent of Chinese territory. In these areas there is a population of 840 million people, and GDP is about 6562.8 billion RMB. These areas are the major regions of Chinese social and economic activities.

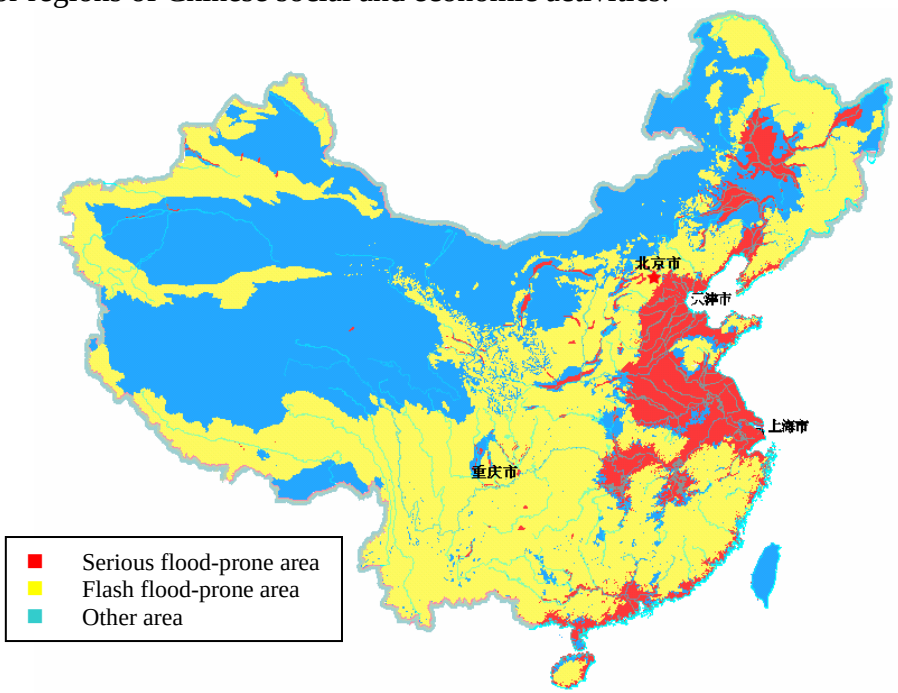

Figure 1 Regions of different flood hazard

In 1990s, annual economic losses caused by floods accounted for 1.7% of GDP. But in developed countries the flood damage rate to GDP is less than 0.5%. In 2005, up to October, 16.26 million hectares of farmlands were affected by flood and waterlogging, 212 million people affected, 1404 people killed in flood and sediment disasters, and the direct economic losses 160.7 billion RMB. Zhejiang, Fujian, Hainan, Guangxi, Sichuan, Anhui, Jiangxi, Liaoning provicnes heavily suffered from flood disasters. Generally speaking, the loss from flood and waterlogging disasters in 2005 was serious as compared with those in recent years.

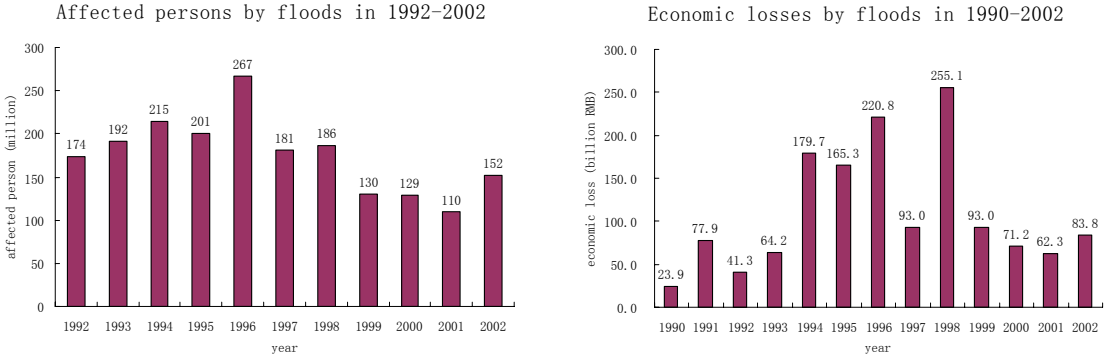

Figure 2 Flood losses of China in 1990-2002

The injury, death and property losses caused by floods, landslide and mudflow, rank the first among all natural disasters in China. Floods seriously threaten the social and economic development. As a significant strategic issue, flood control and flood security attract high attention all over the country.

1.2 Outline of present countermeasures for mitigating flood damages in China

In the late 20th century, the floods in the Yangtze, Nenjiang and Songhuajiang rivers in 1998 were the most serious natural disasters. China made great efforts to implement the project to prevent floods. In China the flood control systems are composed of structural and non-structural measures. Combined these measures, the main goal of flood management is prevention of casualties and reduction of economic losses to the least.

Structural measures are aimed at releasing, detaining, confining, diverting and storing floodwater, to reduce the frequency and magnitude of flooding. Flood control facilities construction in the river basin is the basic way to mitigate flood risk and damage. These facilities include reservoirs, embankments, food detention areas, pumping stations, etc. Reservoirs were constructed in upstream areas to store floodwaters and decrease flood peak, to reduce flood magnitude. Levees and embankments along the rivers were constructed to confine extents of inundation. Flood detention areas, for temporary storage of floodwaters to control discharge to downstream, were built up in the lower rivers.

With the effort of fifty years, the comparable integrated flood and waterlogging mitigation system, which can control normal flood disasters, had been accomplished. It can be summarized as follows: about 246-thousand kilometers levees and embankments constructed; more than 860-thousand reservoirs with a total storage capacity more than 475.1-billion cubic meters; 98 national specified flood detention areas with total capacity near 100-billion cubic meters. According to incompletion statistics, the flood prevention system that has been built has reduced losses of 1,500 billion RMB from floods.

Up to now, the key flood control projects were constructed up in seven major rivers in China. The Xiaolangdi reservoir located at the lower Yellow River commenced its

operation in 2000, to control floods and reduce aggradation rate in the lower Yellow River. Three Gorges Project is under construction, it will be completed in 2009. In Huaihe River, Linhuaigang hydraulic complex project will be completed soon, which will improve the flood control standard in the middle reach of Huaihe River to 100-year flood.

Non-structural measures play a very important role in China. These methods include legal and institutional system, recovery of floodplain storage, flood forecasting and telecommunication system, flood emergency planning and response, and post-flood recovery, etc. These activities directly modify the vulnerability of communities exposed to flood risk.

Till now, China has set up a series of flood control legal and institutional system. Flood Control Law was adopted on August. 29 1997, and came into force on January.1 1998. According to the law, all units and individuals shall have the obligations to protect flood control works and to take part in flood control and flood fighting. The administrative heads of people's governments at all levels have the obligation to assume overall responsibility for the work of flood control, this is the basic rule in Chinese flood management. So the local government, such as province, city and county, should be in charge of flood facilities construction and flood fighting. And central government and Ministry of Water Resources provide capital and technical support separately to the local government. Defense planning for the Seven Large Rivers are compiled by State Flood Control and Drought Relief Headquarters, which comprise the operation principle of flood facilities and the flood fighting obligation of local government concerned.

Recovery of floodplain storage in river systems is also used to increase flood storage capacity. After 1998 flood of Yangtze River, farmlands around the Poyang Lake and Dongting Lake, the two largest lakes in middle stream of Yangtze river, are returned to recover lakes and rivers, 2.42 million affected populations were resettled to nearby places, water area of 2900 km^2 was recovered and flood storage capacity of 13 billion cubic kilometers was increased.

Flood forecasting is another non-structure measure widely used in China. Hydrological information system can collect and disseminate hydrological information promptly, and make hydrological forecasting. The real-time rainfall and flood information of the national hydrological stations can be collected within 30 minutes, and forecasting results can be obtained within 1 hour. The hydrological information is the most important data for flood-decision. Research is ongoing to maintain and improve technical capabilities.

In addition, China has formulated a compensation policy for the local people living inside flood detention areas since 2000. Central and local governments share the expenses on personal property and crop loss compensation due to flood detention in the national flood detention areas. In the past five years, ten flood detention areas were utilized to storage floods, nearly 200 million RMB capitals were compensated for the affected residents.

In 1998, extraordinary severe floods occurred in the Yangtze River basin. Flood-control system construction for rivers is oriented towards harmonious coexistence between man and nature. In other words, floods should be provided a way out, and thoughts should be gradually transformed from endless disorderly struggle for land between man and water to orderly and sustainable harmony between man and flood. A new flood thoughts, transfer from the flood control to flood management, has been brought forward since 2003. So In the process of flood management, flood, drought and water shortage issues are considered concurrently, firstly to ensure the flood safety, and utilize the flood source to mitigate water shortage.

1.3 The function of flood hazard maps in China

Since flooding is a natural phenomenon, it's impossible to prevent flood disasters completely. Although structural measures can control the target floods, in a case where floods exceed target level, the structure measures still could not prevent the occurrence of flood damage. So there is a need for non-structure measure to cope with the floods that exceed the target level, and flood hazard map is a good example of such non-structural measures. In China, flood hazard maps are developed as a multiple-purpose project, expected to achieve several goals.

First goal is to enhance awareness of flood disaster prevention of the nation. "Becoming aware is the step towards preparation". When floods occur, disaster mitigation not only relies on the government activities, but also community and self-help. In areas where flooding has been decreased by flood control facilities, or not suffered from flooding in recent years, the residents tempt to be too optimistic and believe there is no flood danger in the area. It's very necessary to offer flood disaster mitigation education to the public. From flood hazard map, it can awake residents that they still live in the flood-prone area, and the public can obtain effective flood and evacuation information, so it impels residents to think for themselves, bearing in mind the danger of flood damage and to prepare beforehand. As a result, in the emergency of flooding, residents can evacuate in time and reduce the damage loss by themselves.

Secondly, flood hazard map can serve for the flood control and flood fighting decision-making at all levels of Flood Control Headquarters (FCH). In the process of compiling flood hazard maps, such as examining disasters or gathering various kinds of information, FCH can collect more information about flood inundation, acquire experience on how to evacuate residents promptly, enable prompt administration of action on the occasion of the actual flood. And also flood hazard map can be used to offer basic data for assessing flood losses. In the emergency of flooding, important information, such as previous inundation area, affected people, economic loss, can be estimated in advance, so FCH can determine how to operate flood control facilities, such as reservoirs, flood detention areas, and issue evacuation order in time.

Thirdly, flood hazard map can direct the land use plan and construction of safety facilities in the flood detention areas. Flood hazard maps provide a principle for land use plan. In the presumed deep inundation area, it's restricted to develop industry immoderately, otherwise these factories should construct self-guard flood control facilities to ensure safety. And the flood hazard maps can provide reference for land use plan, such as which area is suited for agriculture, industry, entertainment, wetland, etc. There are many people living inside 98 flood diversion and detention areas in China. In order to safeguard their lives at flooding times, live-saving facilities have been constructed, and flood hazard map can provide choose visual and reasonable way and place for evacuating people in emergency.

Finally, using flood hazard maps, flood damage can be reduced by the accurate information and usual countermeasures. The residents know how to get flood information and where, when, how to evacuate, it can shorten evacuation time effectively. Lives will be saved by early escape.

Recently, Office of Flood Control and Drought Relief Headquarters conduct a pilot work to produce flood hazard maps, as a non-structural measure to mitigate the flood hazard.

2. The allocation of roles in making flood hazard maps in China

2.1 Responsibility for making flood anticipated inundation maps (flood risk maps)

The Ministry of Water Resources (MWR) is the ministry of the State Council that is responsible for water administration. One of main responsibilities of MWR is in charge of planning, construction and management of flood control measures. Office of State Flood Control and Drought Relief Headquarters (OSFCDRH) is the special department in charge of national flood affairs in MWR, and also to take the daily work for its Headquarters. Bureau of Hydrology (BOH) is another department of MWR, which provides hydrological, precipitation information and technical support for OSFCDRH.

In China, seven major rivers flow different provinces, in order to coordinate and conduct water-related affairs, River Basin Water Resources Commissions (RBWRC) for the Yellow River, Yangtze River, Hai River, Huai River, Pearl River, SongLiao River and Taihu Lake, have been established. Specific functions for water management and flood protection, such as drafting out flood control planning for major rivers, are implemented through these commissions. For the convenient flood management of river basins, the Yangtze, Yellow, Huaihe and Songhua River have separately established a basin-wide flood control organization, which is under the leadership of SFCDRH. Flood Control and Drought Relief Headquarters at local levels are in charge of flood emergency response affairs at the river basin or the local level.

In my opinion, MWR, OSFCDRH, BOH and RBWRC should take the responsibility for make anticipated inundation area maps of seven major rivers. These institutions have collected the flood disaster information of these rivers, and also are familiar to the flood control planning and facilities. So they can calculate and simulate the inundation area and depths, compile the record and anticipated inundation maps and provide these maps to the respective provincial governments. Provincial Bureau of water resources, and Office of Provincial Flood Control Headquarters are in charge of other rivers flood inundation maps in the jurisdiction. China Institute of Water Resources and Hydropower Research will also play an important role on technical support for the flood inundation and hazard maps.

Flood anticipated inundation maps are mainly used by officials and technicians concerned and provide basic datum and flood information.

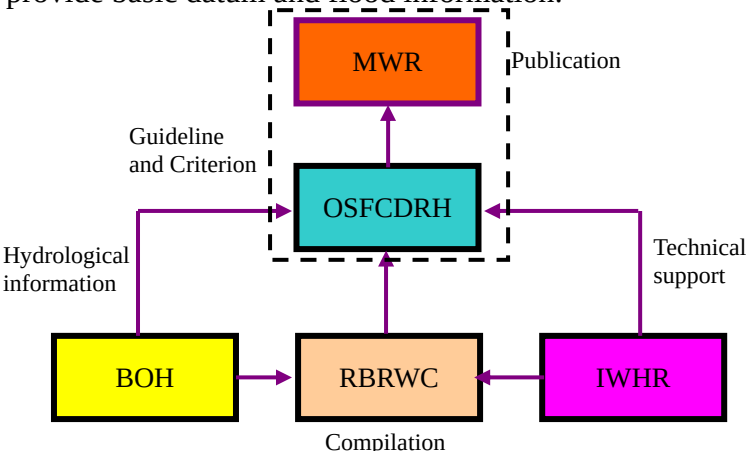

Figure 3. Flowchart of compiling flood anticipated inundation maps of seven major rivers

MWR — Ministry of Water Resources

OSFCDRH — Office of State Flood Control and Drought Relief Headquarters

RBWRC — River Basin Water Resources Commission

BOH — Bureau of Hydrology

2.2 Responsibility for making and disseminating flood hazard maps

In China, governors of local governments, such as province, city and county, are stipulated as the executive official in charge of the local disaster prevention and flood fighting. So the local governments are authorized to issue evacuation orders and supply accommodation for the affected residents. Local governments are familiar to the residents' distribution and topography of its jurisdiction. So it's the local government responsibility to make and disseminate flood hazard maps. Flood hazard map are aimed at the public living in the flood prone areas, to prevent casualties by providing residents with flooding and evacuation information a easy-understanding way.

In detail, Bureau of water resources and Office of Flood Control Headquarters of the local government bear the concrete works, in close cooperation with the local residents, qualified experts, non-governmental organizations and other pertinent bodies.

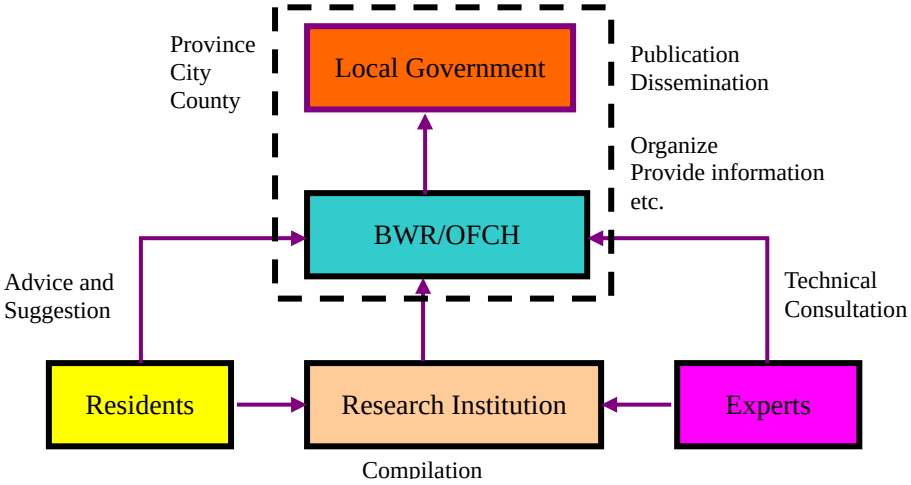

Figure 4. Flowchart of compiling flood hazard maps of administrative jurisdiction
BWR — Bureau of Water Resources of local government
OFCH — Office of Flood Control Headquarter of local government

3. The Action plan of making flood hazard maps in China

3.1 Target river basin areas for flood hazard maps

In my opinion, there are three principles to select the target river basin areas. Firstly, floods occurred in the river in the past years, and some area was submerged, so it's urgently essential to produce flood hazard maps to evacuate residents and reduce loss in emergency of flooding. Secondly, current flood control standard of this area is low and probability of flooding is more frequent. So if flooding occurring, the effectiveness of flood hazard map can be demonstrated in the recent years. Thirdly, the target area is relative with our daily work. Because my division is in charge of Huaihe and Pearl River flood management, different types of target areas are selected from these two rivers. According to my past experience of flood management, I plan to choose mengwa flood detention area to produce the flood hazard maps, and Li river and Wuzhou city as optional targets.

(1) Mengwa Flood detention area

In July. 2003, Mengwa flood detention area, which is located on the north bank of middle Huaihe River, Anhui Province, was utilized to storage floodwater. Nearly 200,000 people have been evacuated to the earth platforms and embankment village polders. During the past 52 years following, this area has been used 12 times in ten years.

Figure 5.Mengwa flood detention inundated in July. 2003

After the flood disaster map completed, we'll disseminate to every household. When flooding, if the flood detention area is determined to utilize, the local government issues order to organize residents to evacuate to designed shelters involved in flood hazard maps. It can shorten evacuation time, ensuring life safety. Local government can assess the inundation extent and damage beforehand, and promptly carry out damage prevention plan.

Residents are aroused to adjust plant category to reduce crop losses according to anticipated inundation duration and depth, such as appropriate places to plant grain, vegetables or fruit.

(2) Li River Basin

In July, 2004, severe flood occurred in Li River, a tributary of Huaihe River, Henan Province. For the floods has exceed the designed flood control standard of levees, nine sites on the embankment were broken. The flood submerged some farmlands, and nearly 20 thousand people were affected. The embankment of Li River only can defend the target flood which occurs once in 10 years. So the flooding is frequent in this area.

Figure 6 Levee break on Li River in July, 2004

(3) Wuzhou City

Wuzhou city is located on north bank of West River, a tributary of Pearl River, Guangxi Province. It is the national important flood control city. In June, 2005, heavy floods with occurrence over 100 years hit Wuzhou city. Since east district of Wuzhou only reaches to 10-year flood control standard, inevitably floods overtopped the top of levees, and nealy 2~3 km^2 area was inundation. West district of Wuzhou the flood standard is 50-year, but the flood level still reached the top of wave-proofing walls. Through sub-embankment construction with sandbags, inundation of west district was successfully avoided. About 200 thousand residents were evacuated to the safe places.

Figure 7. Inundated east district of Wuzhou City (left) and the urgent crisis of west district (right)

3.2 Thoughts of making flood hazard maps in the chosen area

I have collected some datum of these three areas, such as topographical map. But the work of producing flood hazard maps should be done by office of municipal flood control headquarters concerned. I plan to impel Guangxi, Anhui, Henan office of flood control headquarters to develop this work, provide capital budget.

And also I will strive for financial support from the fund of flood control works maintenance and construction. My role is to organize, promote this work, and can also offer technical support and experience obtained from Japanese flood hazard maps.

3.3 My action plan within the next five years

Now, China is formulating the Eleventh Five-year Plan of water-related affairs. Flood mitigation is one important part in the plan, the primary Eleventh Five-year Plan of flood mitigation contains the context of setting up the flood risk maps of the seven largest rivers, and producing the flood hazard maps in partly important flood prone areas.

So my plan is corresponding with Eleventh Five-year Plan of flood mitigation. There are two stages in the process of producing flood hazard maps, first stage is to compile the flood risk maps of seven largest rivers, and second stage is to compile flood hazard maps on basis of flood risk maps. The following is a draft of my action plan:

- Nov. 2005 Report to my office.
  - Introduction of history, procedure, method, effectiveness, practice, etc of Japanese flood hazard maps.
  - Bring forward target areas, to acquire the approval and support of my office.
- Jan. ~ Jun. 2006 Produce record flood maps
  - Cooperate with related provinces office of flood control headquarters.
  - Choose research institutions.
  - Collect past floods information, topography data, flood damage, etc.
  - Compile history inundation maps
- July. ~ Dec. 2006 Produce flood risk maps
  - Through hydraulic calculation and simulation, estimate the anticipated inundation areas (such as extent of inundation, water depth, flow rate, arrival timing etc.)
  - Compile flood risk area
- Jan. ~ April. 2007 Produce flood hazard maps

- Calculation population required to evacuate, accommodation provided by shelters.
- Formulation of an evacuation plan
- Inquire the public suggestion
- Compile flood hazard maps

- May. ~ Jun. 2007 Publication and dissemination of flood hazard maps
  - Approval by the local government
  - Dissemination
  - Flood prevention education in schools
- July. 2007~ 2010 Verification and actual application
  - Survey report and verification the effectiveness of flood hazard maps in the emergency of flooding
  - Modify and improve the flood hazard maps

I also take charge of related woks about flood hazard maps involved in Eleventh Five-year Plan.

3.4 Problems of making flood hazard maps in China

According my cognition, there is no unsolvable technical problem in producing flood hazard maps, but it is time and capital consuming work. The most important things are whether we can collect detailed datum and develop advanced hydrological numerical calculation, and also the experience is also indispensable.

There are three problems we may probably encounter in the process of producing flood hazard maps.

(1) Lack of laws support. Flood Control Law of People's Republic of China came into force as of January, 1998, but no such provision about flood risk and hazard maps were stipulated in the law. So it's not an obligation for local governments to produce flood hazard maps, if local governments are lack of enthusiasm or capital, they may not impel this work.

(2) Large Flood inundation area. Some important embankments of lower major rivers protect wide lands and many residents, and the flood level is several meters higher than the inland ground level. Residents live sporadic in this area and the transportation is not convenient, the farthest evacuation routine may exceed 10 km, so the evacuation time will be very long. In these protective areas, if the levees are broken, large areas and thousands of residents will be inundated, how to estimate the inundation area and establish the evacuation plan is a difficult problem. We should estimate the anticipated inundation area according to the volume of flood water discharging from the levee breaks.

(3) Low flood control standard. Because flood control standard of many levees can only prevent the flood which occurs once in 10 years, in my opinion, 10-year, 20-year, 50-year, 100-year flood, and maximum flood inundation areas should be drawn out in the maps with different colors, so and risk of different flood magnitude can be displayed.

(4) Lack of detail information and experience. Although China Institute of Hydraulic and Hydropower Research is pursuing in the flood risk study, they have taking several pilot study about flood risk, yet this study has not been demonstrated by actual floods. And production of flood hazard maps just starts, now there is no flood hazard map completed.

4. Advices and suggestions

I should express my sincere thanks to JICA, TBIC, PWRI and ICHARM. This training

greatly improves my knowledge of flood hazard maps, and will also benefit flood management of China in the future. There are two suggestions:

- If possible, please arrange trainees to visit MLIT, let trainees further get to know the water-related administrative management in Japan.
- Now PWRI is preparing another training course “Tsunami Disaster Prevention”. China is one of the countries suffered the heavy cyclones, and we hope to exchange information and experiences about cyclone and tsunami prevention. We are expecting JICA, TBIC and PWRI will offer a chance for Chinese participants to attend that course.