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Report on 2007-2008
“Water-related Risk Management Course
of Disaster Management Policy Program”

January 2009



United Nations
Educational, Scientific and
Cultural Organization

International Centre for Water Hazard and Risk Management
under the auspices of UNESCO (ICHARM)
Public Works Research Institute(PWRI)

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Report on 2007-2008 “Water-related Risk Management Course of Disaster Management Policy Program”

Shigenobu Tanaka

Daisuke Kuribayashi

Synopsis:

ICHARM conducted a one-year Master’s program entitled the “Water-related Risk Management Course of Disaster Management Policy Program” for the first time from 30 September 2007 to 19 September 2008 in collaboration with the Japan International Cooperation Agency (JICA) and the National Graduate Institute for Policy Studies (GRIPS).

The eleven students were mainly technical officials, engineers or researchers in the field of river management or water-related disasters in developing countries.

This course aims to foster solution-oriented practitioners with solid theoretical and engineering bases who can serve for planning and practices of flood management within the framework of integrated river basin management at all levels from nations to localities.

In the first half of the course, the students attended mainly lectures and exercises; in the second half, they worked on their individual studies to complete the Master’s theses and visited many places across Japan in several field trips to learn up-to-date flood control countermeasures at work.

This is the report of the course activities and its achievement.

Key Words: Training, Disaster prevention, Flood disaster

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Chapter1 : Background and Objectives

1.1 Global trend of water-related disasters

Natural disasters cause human tragedy and economic loss and hamper the development of countries wherever they occur. In particular, due to recent urbanization in developing countries, there is a common tendency that the poor are forced to settle in buildings and areas that are vulnerable to natural disasters. This considerably discourages developing countries' efforts to alleviate poverty.

Among natural disasters, especially, water-related disasters such as floods and droughts are major challenges that need to be overcome in order to ensure sustainable human development and poverty alleviation. Such devastating disasters have been not only increasing in frequency (Figure 1-1), but also expanding in terms of the extent of damage and impact due to rapid population growth and high concentrations of population and property in urban areas. They also expose high-value assets to the greater risk of disaster damage. According to a UN population projection (UN World Urbanization Prospects 2005), urban population will continue growing in number and proportion across the world, and most of the growth will be seen in developing countries. For example, between 2000 and 2030, urban population in Asia and Africa is projected to rapidly increase from 1.36 to 2.64 billion and 294 to 742 million, respectively (Figure 1-2). Even in 10 years' time, a rapid population growth is projected in major water-front cities in Asia, e.g. Dhaka (Bangladesh), Mumbai (India) and Jakarta (Indonesia). If appropriate measures are not taken to protect those cities from disasters, their vulnerabilities to major water disasters, such as floods, storms and tsunamis, are likely to become increasingly high (Figure 1-3).

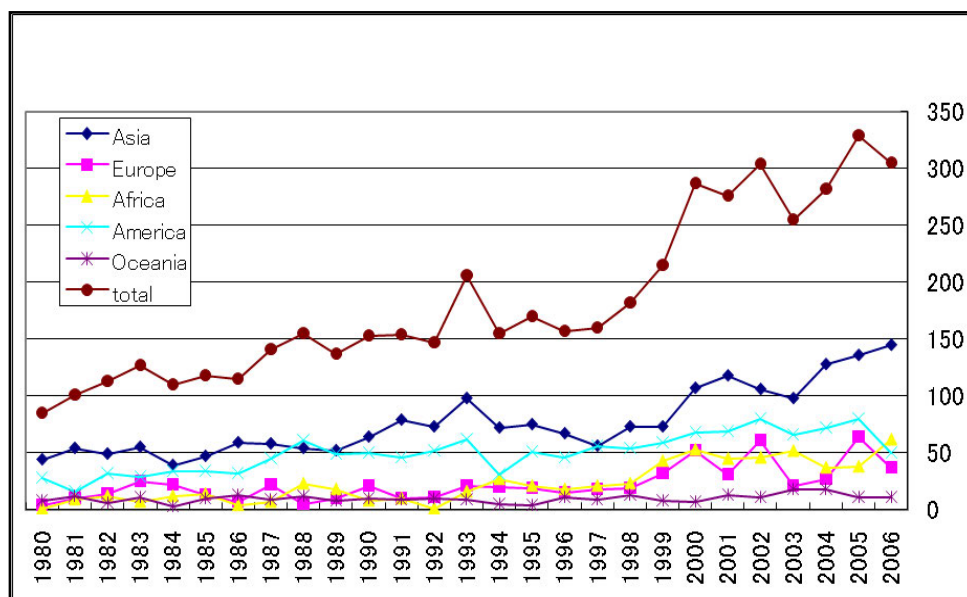


Figure 1-1 Annual change in the number of water-related disasters

(Made by ICHARM based on CRED EM-DAT)

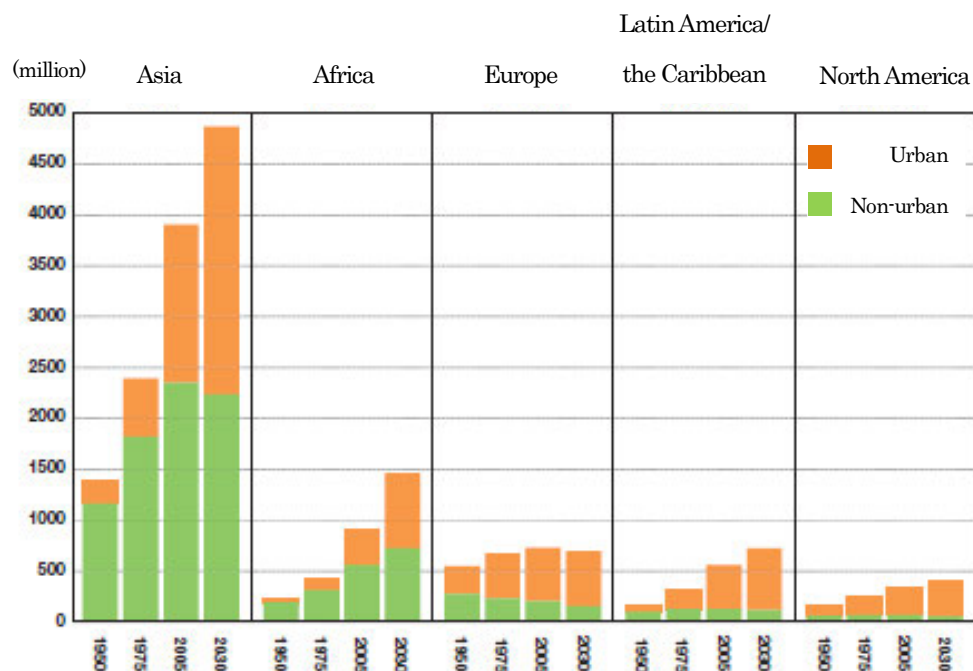


Figure 1-2 Demographic change in urban and non-urban areas by region

(Made by ICHARM based on World Urbanization Prospects:

The 2005 Revision by Population Division, Department of Economic and Social Affairs, UN)

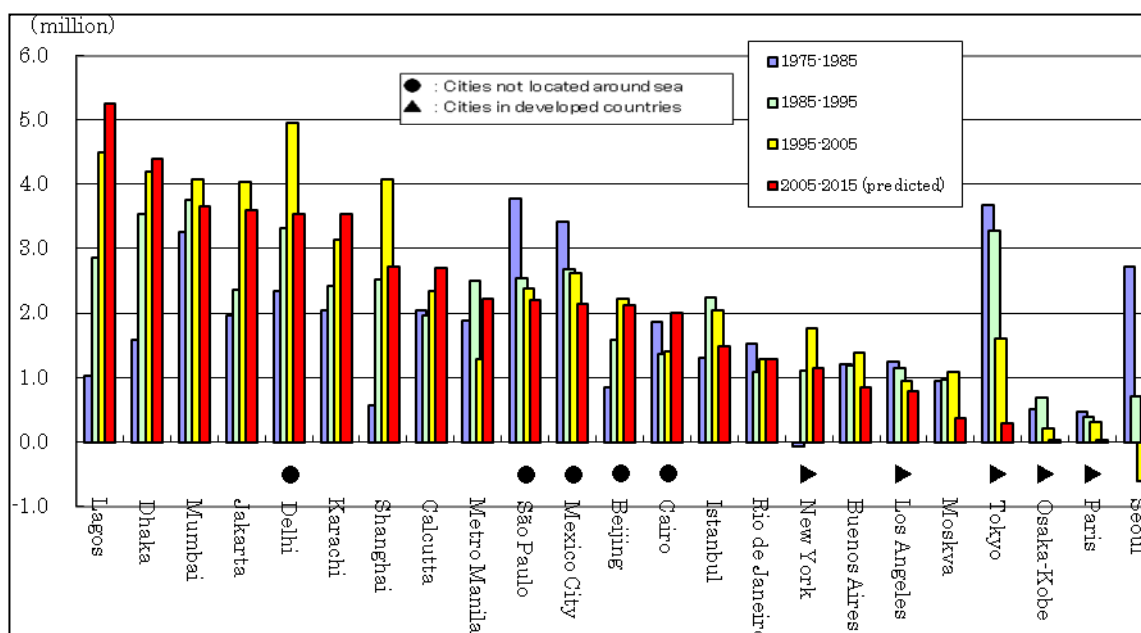


Figure 1-3 Demographic change in major cities worldwide between 1975 and 2015

(Made by ICHARM based on World Urbanization Prospects:

The 2005 Revision by Population Division, Department of Economic and Social Affairs, UN)

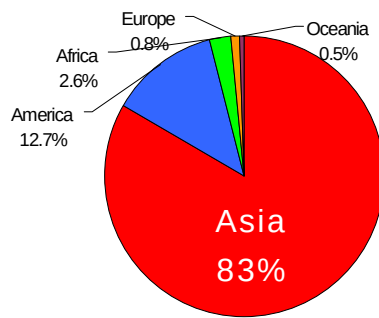


Figure 1-4 Distribution of the fatalities due to water-related disasters (1980-2006)

(Made by ICHARM based on CRED EM-DAT)

Asia alone accounts for over 80% of the worldwide fatalities due to water-related disasters (Figure 1-4). Looking ahead, precipitation and its distribution patterns are predicted to change due to climate change, and this may exacerbate the intensity and frequency of water-related disasters. Sea level is expected to rise worldwide due to global warming, which in turn will worsen the exposure of coastal areas, delta areas at the lower reaches of rivers, and small islands.

1.2 Launch of a Master's course in disaster management

In order to reduce the impacts of natural disasters, well-balanced risk management before, during, and after disasters must be established in a multi-disciplinary way. To meet this need, disaster management experts must be fostered through professional education and training so that they can develop appropriate disaster management policies and techniques based on local conditions and needs, and communicates with local people to raise awareness toward disaster prevention in communities.

Under such circumstances, in order to enhance the capacity of experts in developing countries to cope with natural disasters, ICHARM, the National Graduate Institute for Policy Studies (GRIPS) and the Japan International Cooperation Agency (JICA) jointly launched a Master's degree program entitled the "Water-related Risk Management Course of DISASTER MANAGEMENT POLICY PROGRAM" in 2007.

The United Nations designated 2005–2014 as the Decade for Education and Sustainable Development under the initiative of the United Nations Educational Scientific and Cultural Organization (UNESCO). This Master's course is exactly in step with the spirit of the Decade. ICHARM is honored to be one of the organizers considering that the centre is established under the auspices of UNESCO.

1.3 Objectives of the Master's course

To cope with the situations as explained in 1.1, it is urgently needed to foster experts in water-related disaster management in developing countries. They need to learn a wide range of knowledge necessary for disaster risk management from technical and social viewpoints in preparedness, restoration and rehabilitation.

This course aims to foster solution-oriented practitioners with solid theoretical and engineering bases who can serve for planning and practices of flood management within the framework of integrated river basin management at all levels from nations to localities.

Through the Master's training course, students are required to:

- Acquire basic knowledge and techniques for water-related disaster mitigation in the field of hydrology, hydraulics, integrated flood risk management, hazard mapping, sustainable reservoir development, and control measures for landslides and debris flows;
- Learn theories on which water-related risk management policies are based and study and understand Japanese policies and systems; and
- Improve the problem-solving capability to develop appropriate technologies and policies specific to local conditions.

1.4 Characteristics of the Master's course

This training course is characterized by the following five points:

“Problem Solving-Oriented” course

To cope with major disasters, it is essential to develop organizational capabilities in disaster management as well as those of individuals in the organization, because there is always limitation for what each person can do.

Take JICA training courses for example. They were previously conducted with focus on “capacity building of individuals.” Recently, however, JICA has shifted its training focus from capacity building to problem solving, in which the agency designs “solution-oriented” courses to increase organizational capabilities in disaster management. This shift of the course emphasis is based on the idea that training will also be more effective and efficient for each student when they first identify water issues specific to their countries and then proactively study to solve those issues. This type of training is also considered to produce extremely desirable outcomes for organizations from

which the students are sent, because their products are directly related to the issues they face.

Based on this course philosophy, the training course is designed to be not “a course in which students are somehow forced to study” but “a course in which they independently think and find solutions to issues of their interest.” One of the graduating requirements of this course is to write a Master’s thesis on an issue to which each student identifies and finds a solution by him/herself. Such assignment helps students develop the capacity to formulate integrated flood mitigation plans and also will help them address other issues at home.

“Students from the same organization”

This training course is part of a project designed to conduct a Master’s course three times within three years. As mentioned earlier, to develop organizational capabilities in disaster management, the course organizers strategically recruit several students from the same organization to the training. The organizers also make direct requests for organizations in the target countries to send capable students (see Chapter 6).

“Students from the same country”

In the same context, the course organizers make efforts to recruit several students from the same country in the same year, if impossible from the same organization. In this way, they can effectively study and interact with each other to contribute to their home country.

“Practical rather than Theoretical”

To make the training course solution-oriented, lectures and exercises which are practical rather than theoretical are provided in the course to prepare students to be fully functional in actual situations. In this sense, field trips are a crucial part of the training course.

“One-year Master’s course”

The target population of this training course is incumbent practitioners working in administrative organizations. For that reason, the course is designed for them to earn a Master’s degree within a single year rather than the usual two years so that they don’t have to be absent from work too long.

1.5 Outputs of the Master's course

Through this course, students will become:

- (1) Knowledgeable about the recent practices in integrated flood risk management in various localities in the world.
- (2) Able to define requirements for local/national effective risk reduction, including public policies, and arrange local/national risk management frameworks, institutional coordination, and management mechanisms including all stakeholders.
- (3) Able to develop local/national indicators to detect and monitor changes in policies for emergency response and disaster risk reduction, as well as to monitor the status and effectiveness of those policies.
- (4) Able to contribute to the implementation of plans based on new integrated risk management policies developed in clear financial, institutional and legislative frameworks.
- (5) Able to develop risk management strategies covering all the management cycle components of emergency response, recovery, mitigation and preparedness, considering risk detection and communication issues as well as emerging threats, such as global warming and climate change.

After the course, students are expected to:

- (1) Identify issues and tasks that their home countries are facing based on the understanding of the historical, institutional and legislative backgrounds of flood disaster management in Japan, and finally draw up action plans to overcome those issues and to undertake relevant tasks.
- (2) Realize the need of flood disaster reduction schemes in their home countries, and plan flood-disaster prevention/reduction projects and finally draw up workable action plans.
- (3) Understand and acquire knowledge and techniques in flood risk assessment and risk reduction and create flood hazard maps.
- (4) Understand and acquire knowledge and techniques in project planning for flood control (including dams and sediment control), figure out tasks to be performed in target river basins in their home countries, and finally draw up detailed action plans, which need to be tested for its validity during the training course.

1.6 Other information of the Master's course

The candidate countries, target organizations, number of the students and duration of the course

are as follows:

Candidate Countries;

Eight countries

(Afghanistan, Bangladesh, China, Ethiopia, India, Nepal, the Philippines, and Thailand)

Eligible/Target Organizations:

Technical officials, engineers or researchers in the field of river management or
water-related disasters

Total Number of Students:

11 students: Bangladesh (2), China (3), Nepal (1), India (1), the Philippines (1)
and Japan (3)

(One student returned to his country due to health issues in October 2007.)

Duration:

30th September 2007– 19th September 2008

Chapter2 : Preparation for the Master's course

2.1 Recruiting procedure

Under the circumstances explained in Chapter 1, to attract a wide range of students worldwide, the recruitment was carried out in two ways: JICA and general recruitment. The former was conducted through JICA local offices and students were considered as JICA students.

2.1.1 JICA recruitment

To recruit students, the General Information was prepared in a joint effort between JICA and ICHARM and distributed to the target countries in February 2007, about six months before the training course started. The General Information is included in Reference 1 of this report.

In June 12 and 14, 2007, which was before the application deadline, TV conferences were held between JICA local offices and the JICA Tsukuba Office using the JICA-Net TV conference system. With the year 2007 the first year of the training course and also to recruit highly-motivated students, personnel at JICA local offices needed to adequately understand the intention of the training course. Responding to the request to attend the conferences, many of the local offices in the target countries – the Philippines, Bangladesh, India, Thailand and Nepal – joined the meeting (Table 2-1).

Actually, the offices that responded positively to the plan sent motivated students to the training. Besides, the conference was useful to see how responsive each JICA local office was.

Table 2-1 TV conference schedule

Date	Country	Time (Local Time)
12 th June, 2007	Philippines	15 : 00-16 : 00 (14 : 00-15 : 00)
	Bangladesh	16 : 30-17 : 15 (13 : 30-14 : 15)
14 th June, 2007	India	12 : 30-13 : 30 (9 : 00-10 : 00)
	Thailand	15 : 30-16 : 30 (13 : 30-14 : 30)
	Nepal	16 : 30-17 : 15 (13 : 15-14 : 00)

2.1.2 General recruitment

To make this training opportunity open to those outside the target countries of JICA training, the

National Graduate Institute for Policy Studies (GRIPS) posted the recruitment information (see Reference 2) on their website for about two months.

Four people (three Japanese and a Chinese) applied to the course and were successfully admitted after the selection process.

2.2 Student list

After the selection process, a total of eleven applicants (seven from the JICA recruitment and four from the general recruitment) were admitted to the training. The list of the first class of students is included in Reference 3 at the end of this report. Unfortunately, Mr. Ragon from the Philippines had to return and could not complete the training due to health issues.

2.3 Course curriculum

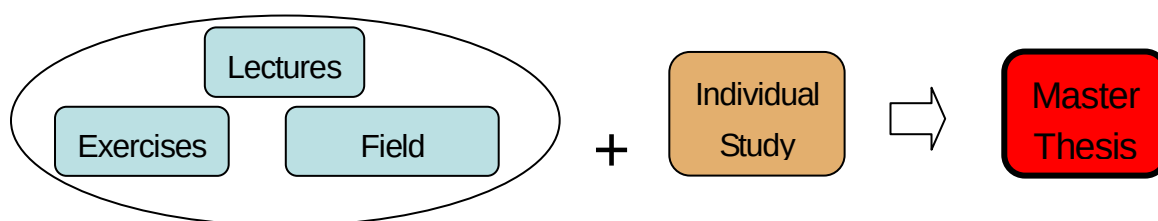


Figure 2-1 Concept of the Master's course

The course consists of eleven lectures, six exercises, five field studies and an individual study (Figure 2-1). Each lecture and exercise consists of 15 classes. Reference 4 shows the list of names, credits and lecturers of the lectures and exercises. As this is a problem solving-oriented, practical course, the lectures cover not only the fundamentals but also applications and many kinds of exercises in water-related risk management. Reference 5 shows the detailed course syllabus and Reference 6, the table of all classes.

Each lecture counts for two credits, each exercise for one (except for "Practice on Hydraulics"), and the individual study for 10. Students must complete a minimum 30 credits, 16 of which must come from the "Recommended" subjects. A student can be conferred a Master's degree in disaster management if his/her Master's thesis is accepted after satisfying the credit requirement. Reference 7 shows a sample of the original certificate issued by GRIPS and ICHARM.

The course was taught by not only ICHARM researchers but also many prominent researchers and professors for students to learn up-to-date knowledge in water-related fields. Reference 8 shows the list of the lecturers.

2.4 Course schedule

The lectures started from the second week in October, which includes the International Day for Natural Disaster Reduction. Figure 2-2 shows the outline of the course schedule.

In the first half of the course, the students attended mainly lectures and exercises; in the second half, they worked on their individual studies to complete the Master's theses and visited many places across Japan in several field trips to learn up-to-date flood control countermeasures at work.

Reference 9 shows the detailed schedule of the first half of the course.

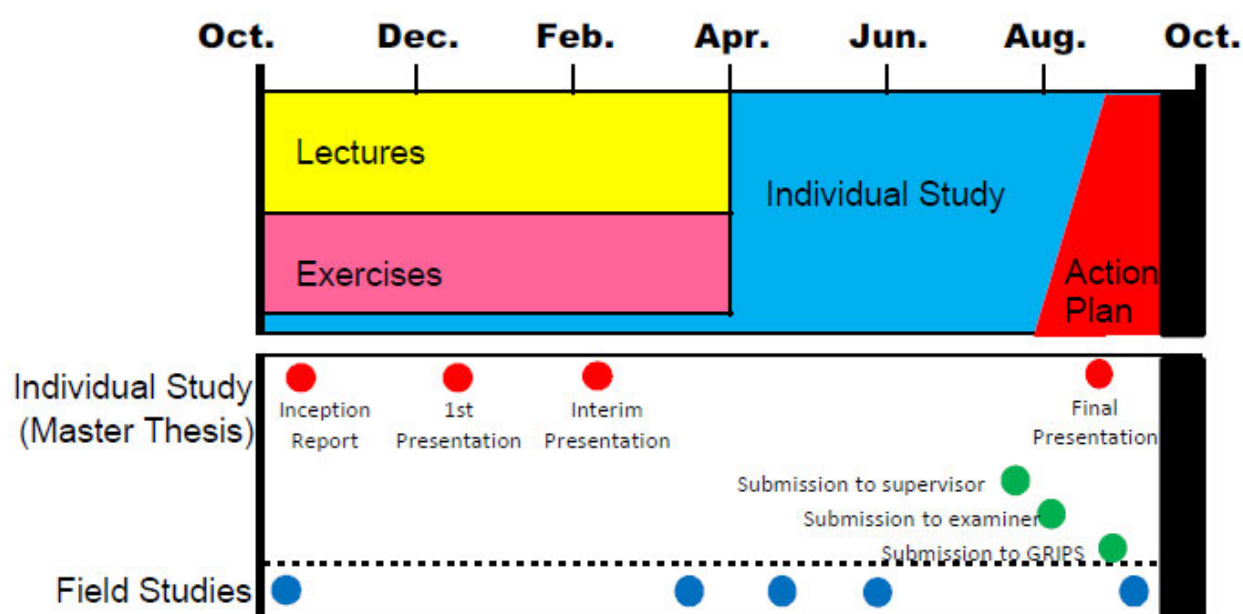


Figure 2-2 Outline of the course schedule

2.5 Field studies

The training course provided the students with five field-trip opportunities in total to have good understanding of flood control in Japan (Table 2-2). The detailed itineraries of the trips were included in Reference 10. Table 2-3 shows photos from each trip.

Table 2-2 List of field-trip destinations

Date	Destinations (Prefecture)	Targets for field study
November 2007	Kumozu River (Mie) Miya River (Mie)	-Kasumi-tei levee (discontinuous levee) -Damage by heavy rain in 2004
March 2008	Kaike Coast (Tottori) Hii River (Shimane) Obara Dam (Shimane) Nukui Dam (Hiroshima) Ohta River (Hiroshima) Disaster Reduction and Human Renovation Institution (Hyogo)	-Coastal erosion control -Discharge channel construction -Consideration for the public concerning dam construction -Dam management -River planning -Disaster management efforts
April 2008	Kanda River Underground Regulating Pond (Tokyo) Tsurumi River Multi-purpose Runoff Retardation Area (Kanagawa) Kirigaoka Regulating Pond (Kanagawa) Tamagawa Levee Break Point (Tokyo)	-Flood control in the Tokyo metropolitan area -Flood control basin project -Integrated flood control -History of flood control
May 2008	Watarase Retarding Basin (Tochigi) Kinu River Dam Integrated Dam Management Office (Tochigi) Ikari Dam & Kawaji Dam (Tochigi) Nikko Sabo & Ashio Sabo (Tochigi)	-Flood control basin project -Integrated dam management of multiple dams -Integrated dam management -Sabo project
September 2008	Imo River Sabo Project (Niigata) Shinano-Ohkouzu Rivers Diversion Channel (Niigata) Tateyama Sabo Project (Toyama) Natural dams in Iwai River (Iwate) Ichinoseki Retarding Basin (Iwate)	-Damage caused by Chuetsu Earthquake in October 2004 -Diversion channel project -Sabo project in the Joganji River upstream area -Damage caused by Iwate-Miyagi Inland Earthquake in June 2008 -Flood control basin project

The field-trip destinations were selected for the students to study the actual conditions of the places that were mentioned in the lectures (e.g. Tama River, Shinano River, etc.). The field trips were also arranged for them to have exceptionally valuable experience; for instance, they had a rare opportunity to visit affected areas, including the Iwai River in Iwate Prefecture, which had hit by a major inland earthquake in June 2008. They were also given a chance to interview the staff of a local MLIT office and ask how they were actually coping with the situations after the quake. Also, some of the trips were designed to have an overall view of an entire basin from the upper to lower reaches; the Hii and Ohta Rivers were such examples.

Field trip reports were assigned to the students so that the trips were not just visits to famous or rare places but part of the study in order to have better understanding of what they had learned. However, the trip in September was an exception in that reports were not assigned to them because it was conducted after the judgment of Master's degree. Nonetheless, the trip itself turned out to be so educational and insightful for the students that it will be scheduled earlier from the next year on.

Table2-3 List of field study sites

November 2007	1. Kumozu River (Open Levee) 	2. Upper reach of the Miya River (Slope failure) 
	3. Lower reach of the Miya River (Disaster Prevention Activity) 	3. Lower reach of the Miya River (Embankment) 
	4. Kaike Coast (Coastal engineering) 	5. Hii River (River Planning) 

6. Obara Dam
(Dam construction)



7. Nukui Dam
(Dam operation)



8. Ohta River
(River planning & management)



9. Disaster Reduction and Human
Renovation Institution (Disaster
prevention)



10. Manda-no-Tsutsumi History
(the oldest levee in Japan)

11. Lake Biwa Canal
(History)



April 2008	12. Kanda River Underground Regulating Pond (Diversion channel) 	13. Shukugawara Weir (Breach point) 
	14. Tsurumi River Multi-purpose Runoff Retardation Area (Retarding basin) 	15. Kirigaoka Regulating Pond (Regulating pond) 
May 2008	16. Watarase Retarding Basin (Retarding basin) 	17. Kawaji Dam 18. Ikari Dam (Integrated dam operation) 

19. Sabo Work in Nikko (Sabo works)



Conveyance pipes connecting the two dams



20. Sabo works in Ashio
(Sabo works)



21. Yattajima Observatory
(Hydrology)



23. Shinano River Ohkouzu Museum
(River planning & management)



“Those who feel heavenly intention in every phenomenon around will be blessed with happiness. / See gods / a god in everything around you, and that will bring you happiness. “

September,
2008

22. Sabo Works in Imo River (Sabo works)



24. Sabo Works in Mt. Tateyama (Sabo works)



25. Kurobe Dam
(Dam operation)



26. Isawa Dam
(Dam construction)



27. Natural Dams in Iwai River by the earthquake (Sabo works)



28. Ichinoseki Retarding Basin (Retarding basin)



Chapter3 : Activity Report of 2007-2008 course



The first class of graduates from the Master's program gathers for photos at the front gate of the National Graduate Institute for Policy Studies (17 September 2008).

<Course schedule>

30 th September	Arrival in Japan
4 th October	Opening Ceremony and Opening Party in ICHARM
11 th October	Country Report Presentation
During November	Joint classes with the Flood Hazard Mapping training course
13 th -16 th November	Field trip & the Town Watching exercise in Ise City
21 st November	Field trip to the Ninomiya Sontoku Museum
6 th & 7 th December	First presentation on Master's Thesis
22 nd January	Special Lecture by Prof. Takahashi
28 th January	
-8 th February	Lectures at GRIPS
14 th February	Second presentation on Master's Thesis
12 th -15 th March	Field trip to the Chugoku and Kinki Regions
4 th April	Cherry blossom viewing and tea ceremony at PWRI
22 nd -23 rd April	Field trip to the Tokyo Metropolitan Area
28 th -29 th May	Field trip to the Kanto Region (Dam & Sabo works)
22 nd August	Final Presentation on Master's Thesis
28 th August	Submission of Master's Thesis
8 th -11 th September	Field Trip to the Hokuriku & Tohoku Regions
17 th September	Graduation Ceremony at GRIPS
18 th September	Closing Ceremony at JICA
19 th September	Departure from Japan

Out of eleven who initially started this program, ten students (three each from China and Japan, two from Bangladesh, one each from Nepal and India) finally fulfilled the graduating requirements and were granted a Master's degree in disaster management. After the graduation ceremony, the first class of graduates proudly went back to their home countries with their enhanced expertise.

This Master's program is unique in several points. For example, students need only one year to earn a Master's degree. Also, the program emphasizes the problem-solving capability. To this end, it is designed to help students enhance their capacity to come up with and propose solutions to problems they are facing in their home countries. Additionally, the program focuses more on practical than theoretical aspects of disaster management.

Reflecting the uniqueness of the program, its annual course curriculum was arranged to intensively provide students with lectures and exercises in the first six months.

Lectures and exercises cover a wide variety of issues necessary to have good understanding of disaster management. Theoretical and fundamental subjects include "Disaster mitigation policy", "Disaster risk management", "Hydrological observation, modeling & forecasts", and "Hydraulics", while practical ones cover "Integrated flood risk management", "Hazard mapping and evacuation planning", "Sustainable reservoir development & management", "Control measures for landslide & debris flow", and "Introduction to International Cooperation". In September 2007, the students of the "Flood Hazard Mapping" training course, also organized by JICA and ICHARM, joined those of the Master's program to take part in lectures and exercises for flood hazard mapping and evacuation planning.



The students listen to a lecture with those of the "Flood Hazard Mapping" training course.



The students listen to a lecture by Prof. Fukuoka of Chuo University

This joint class consisted of 30 students in total from 13 countries, including Bangladesh, Cambodia, China, India, Indonesia, Japan, Laos, Malaysia, Nepal, the Philippines, Sri Lanka, Thailand, and Vietnam. It was an inspiring experience for each student to study with this many people with different nationalities and backgrounds.

In the second half of the program, each student was required to write a Master's thesis, which should also be an action plan to contribute to the reduction of water-related disasters in his or her country. Also, the students took field trips to several major rivers across Japan. The field trips were arranged for them to have better understanding of flood management in Japan and help them come up with practical solutions for flood management in their countries. Some of the field-trip destinations were: the Chubu area including the Kumozu river and Miya river (November 2007); the Chugoku area including the Hii river and Ohta river (March 2008); the Tokyo area including the Kanda River Underground diversion channel, the Tsurumi River Multi-purpose Runoff Retardation Area, and the Tama river (April 2008); the Kinugawa River for its integrated dam management and the Nikko/Ashio area for sabo management (May 2008); the rivers of Imo river, Shinano river, and Iwai river (Iwai river was affected by the Iwate-Miyagi Inland Earthquake), the Kitakami river for the Ichinoseki Flood Control Basin, and the Tateyama area for sabo management (September 2008).



The students visit the Tsurumi River Multi-purpose Runoff Retardation Area.



The students visit a natural dam site along the Iwai River.

The students were diligently engaged in lectures and exercises while having some difficulty living in an unfamiliar environment for a long period of time. In particular, when working on their Master's theses, they spent many hours in a study room at ICHARM completing the theses while getting helpful advice from ICHARM researchers. On 22 August 2008, they presented their theses at the ICHARM Auditorium in front of researchers.

A program of this kind helps not only students but ICAHRM as well. The program is a great opportunity for students to increase their professional knowledge by working on their theses. At the same time, it greatly helps ICHARM itself to build closer relationships with students and create and spread a global network through them. Such a network will surely contribute to future ICHARM activities to a great extent.



The student made presentations
of the master's thesis .

On 17 September 2008, the graduation ceremony was held at GRIPS, followed by the closing ceremony at the JICA Tsukuba Office on the next day. Mr. Mitra Baral of Nepal was awarded the “Outstanding Award” by ICHARM for his highest technical achievement in this one-year Master's program.



Dr. Takeuchi, director of ICHARM, gives a diploma to a
student at the graduation ceremony.



Mr. Mitra is awarded the Outstanding Award by Dr.
Takeuchi, director of ICHARM,
for his distinguished achievement.

Chapter 4 : Master's Thesis

To start working on their Master's theses, the students were first asked to make presentations on their tentative themes for the theses in December 2007. Many of them chose flood hazard mapping for the theses, probably because during the previous month before the presentation, they had a month-long series of lectures and exercises on the topic. In February 2008, the second



Master's thesis presentation was held, and the students made a final decision on their themes.

The students finally started concentrating on their theses around late March, when the required lectures and exercises were all finished. Discussing with ICHARM researchers, they continued working hard on their theses and submitted them to their examiners and supervisors by mid August. All the students were awarded a Master's degree in disaster management after close examination of the submitted theses.

Table 4-1 shows the thesis title and examiner and supervisor of each student. Reference 11 shows the synopsis of each thesis.

Table 4-1 List of Master's Thesis Title

Name	Title	Examiner/Supervisor
Mr. DAI, Ming-Long (China)	DAM-BREAK FLOOD ANALYSIS IN MID-DOWN STREAM OF HAN RIVER	Prof. Jayawardena Amithirigala(ICHARM) Prof. Shigeru Morichi (GRIPS), Ass. Prof. Junichi Yoshitani (ICHARM), Ass. Prof. Pham Thanh Hai (ICHARM)
Mr. Khanindra BARMAN (India)	DEVELOPMENT OF FLOOD FORECASTING MODEL IN BRAHMAPUTRA VALLEY OF INDIA	Prof. Jayawardena Amithirigala(ICHARM) Prof. Kenji Okazaki (GRIPS), Ass. Prof. Kazuhiko Fukami (ICHARM), Ass. Prof. Pham Thanh Hai (ICHARM)
Mr. Md. Aminul ISLAM (Bangladesh)	Flood Hazard Mapping of Dhaka-Narayanganj-Demra (DND) Project using Geo-informatics Tools	Prof. Kuniyoshi Takeuchi (ICHARM) Prof. Kenji Okazaki (GRIPS), Prof. Shigenobu Tanaka (ICHARM), Ass. Prof. Jun Magome (ICHARM)

Mr. Mitra BARAL (Nepal)	Rainfall run off modeling and inundation analysis of Bagmati river at Terai region of Nepal	Prof. Jayawardena Amithirigala(ICHARM) Prof. Shigeru Morichi (GRIPS), Prof. Shigenobu Tanaka (ICHARM), Ass. Prof. Kazuhiko Fukami (ICHARM)
Mr. Muhammad MASOOD (Bangladesh)	Flood hazard and Risk Assessment in Mid-Eastern part of Dhaka, Bangladesh	Prof. Kuniyoshi Takeuchi (ICHARM) Prof. Kenji Okazaki (GRIPS), Prof. Shigenobu Tanaka (ICHARM), Ass. Prof. Pham Thanh Hai (ICHARM)
Ms. YE, Li-Li (China)	Flood Risk Analysis and Risk Management in Mengwa Detention Basin	Prof. Jayawardena Amithirigala(ICHARM) Prof. Kenji Okazaki (GRIPS), Ass. Prof. Junichi Yoshitani (ICHARM), Ass. Prof. Jun Magome (ICHARM)
Mr. Yasuo Kannami (Japan)	Establishment of Country-based Flood Risk Index	Prof. Kuniyoshi Takeuchi (ICHARM) Prof. Shigeru Morichi (GRIPS), Ass. Prof. Junichi Yoshitani (ICHARM), Prof. Shigenobu Tanaka (ICHARM)
Mr. Hirohisa Miura (Japan)	THE ANALYSIS OF FLOOD RISK AWARENESS AT RESIDENT LEVEL IN MEKONG RIVER BASIN	Prof. Kuniyoshi Takeuchi (ICHARM) Prof. Kenji Okazaki (GRIPS), Ass. Prof. Katsuhito Miyake (ICHARM), Ass. Prof. Jun Magome (ICHARM)
Mr. Ryota Ojima (Japan)	Impact Assessment of road construction on the flood inundation in Dhaka, Bangladesh	Prof. Kuniyoshi Takeuchi (ICHARM) Prof. Kenji Okazaki (GRIPS), Ass. Prof. Katsuhito Miyake (ICHARM), Prof. Shigenobu Tanaka (ICHARM)
Mr. Ji Zhou (China)	A NUMERICAL STUDY ON THE OPEN CHANNEL NETWORK IN WUXI CITY "	Prof. Jayawardena Amithirigala(ICHARM) Prof. Shigeru Morichi (GRIPS), Ass. Prof. Kazuhiko Fukami (ICHARM), Ass. Prof. Katsuhito Miyake (ICHARM)

Chapter 5 : Course Evaluation and Issues for Future Improvement

5.1 Course evaluation by the students

Throughout the training, the course evaluation by the students was conducted four times in total. JICA staff was invited to each evaluation meeting, and the meetings provided precious opportunities for them to listen directly to the students' feedbacks on the course.

Table 5-1 Evaluation meetings held during the training course

Date	Evaluation topic
First interim meeting (Dec. 20, 2007)	-Living/learning environment at PWRI and JICA -Lectures and lecturers (general impression, etc.)
Second interim meeting (Jan. 25, 2008)	-Evaluation of lectures excluding "Dam Engineering" and "Sabo Engineering" and suggestions for improvement
Third interim meeting (March 28, 2008)	-Evaluation of "Dam Engineering" and "Sabo Engineering" -General comments after the first half in the training and suggestions for improvement
Final evaluation meeting (Sep. 18, 2008)	(ICHARM) -Evaluation on the Master's thesis process -Comments on implementation of their action plans in their home countries -Evaluation on the field trips (JICA) 1. Suitability of the achievement goal set by the organizer with the actual needs 2. Curriculum evaluation 3. Length of the training period 4. Teaching method 5. Textbooks, training tools and facilities 6. Training course management 7. Satisfaction level to the original expectation 8. Achievement level to the original goal

In each evaluation meeting, the students were encouraged to express their honest opinions about lectures and lecturers, field-trip arrangement, suggestions to improve the living and learning environment at PWRI and JICA Tsukuba, and other related issues.

The following are analyses of the evaluation results on four different aspects of the training course: namely, 5.1.1 Improvement made based on the evaluation meetings; 5.1.2 Evaluation on lectures and lecturers; 5.1.3 Evaluation on the field trips; and 5.1.4 Evaluation on the whole training course.

5.1.1 Improvement made based on the evaluation meetings

As mentioned earlier, a total of four evaluation meetings were held throughout the training course to get feedbacks from the students. Out of the four, three were held in the middle of the training and one at its very end. In the three interim meetings, the students expressed comments shown in Table 5-2, and easy requests were immediately taken care of. Difficult ones were later incorporated in the 2008 training plan and curriculum as much as possible.

Table 5-2 Students' feedbacks at the interim meetings and the organizer's responses

	Students' feedbacks	Organizer's responses
Lectures	Lectures are too many to understand well. They should be reduced in number and more time should be allocated for review.	From December on, The daily number of lectures was reduced to three per day.
	Some lectures overlap in content, repeating the same content in different lectures (especially, IFRM (1) and (2)).	Lectures containing the same content were reorganized in the 2008 training plan.
	Some lectures were not well prepared in terms of textbooks, teaching materials, etc.	Requests were made for lecturers to prepare their lecture materials as well as possible.
	Hydrology was rich in content and the class went very fast. More time was needed to review the content.	Hydrology was divided into two levels – basic and advanced – in the 2008 training course plan.
	Hydraulic lectures and exercises should be designed to be closely related to each other.	They were arranged as requested for the 2008 training course.
Lecturers	Lecturers' English levels are important and need to be checked in advance.	Efforts will be made to check their English levels.
	Some lecturers prepared only reading materials – no charts or tables to help students' understanding.	Lecturers were asked to prepare charts and tables to explain for better understanding.
	Some lectures just talked and didn't encourage discussions between them and	For the 2008 training, lectures were arranged to have two or more lectures to

	the students (especially, when they had to lecture only once).	promote discussion between the lecturers and students.
	Merely reading the contents on so many Power Point slides is not good enough. Lecturers should always check the students' understanding.	Requests were made for lecturers to prepare their lectures as well as possible.
Training Course	More field trips are necessary to understand the present status of flood-related facilities and structures in Japan.	Field trips were arranged to start from March 2008, when lectures will have been all finished.
	More time should be provided before exams.	More time was provided to prepare for exams in the 2008 training.
Living/learning environment at PWRI	-Lectures were too long. An hour and 15 minutes should be appropriate. -The daily schedule was too tight. Lectures should be one hour long.	The length of a lecture is still set for 90 minutes, but lecturers will be asked to take a break in the middle of the class, after 45 minutes or so.
	A high-spec printer should be available for students' use.	The printer was repaired.
	JICA buses come too early to pick up students.	The bus schedule was changed.
	During the lunch time, there is always a long line for the microwave.	Another microwave was purchased at the cost of PWRI.
Living/learning environment at JICA Tsukuba	JICA buses should be allowed to drive in the PWRI property.	JICA buses were allowed to drive in the PWRI property.
	The Internet should be available for each student.	The Internet access for each room was arranged.
Individual study	It would be great if students were allowed to be part of the ICHARM research teams.	The possibility will be explored to see if that is possible.
	It is difficult to collect necessary data for being far away from the home country.	Requests will be made to supervisors in the students' workplaces to provide adequate support.
	A lot of time is spent for lectures at this moment and it is difficult to focus on independent study.	The training course was arranged to provide sufficient time for the students to focus on their independent study from April on.

5.1.2 Evaluation on lectures and lecturers

The following evaluation report is based on the results of the second and third interim meetings. In the second meeting, the students were asked to answer questions on lectures and lecturers excluding those for “Dam Engineering” and “Sabo Engineering,” on which they were asked to answer questions in the third meeting.

The students were asked to answer the questions below:

(Second meeting)

- (Q1) Please fill in the name and the reason of the best 3 useful lectures for the water-related disaster mitigation in your country.
- (Q2) Please fill in the name and the reason of the best 5 lecturers (Except for ICHARM Staff).

(Third meeting)

[Dam Engineering]

- (Q1) Please fill in the name and the reason of the best 3 useful lectures in the subject of Sustainable Reservoir Development & Management for the water-related disaster mitigation in your country.

[Sabo Engineering]

- (Q2) Please fill in the name and the reason of the best 3 useful lectures in the subject of Control Measures for Landslide & Debris Flow for the water-related disaster mitigation in your country.

5.1.2.1 Results of the second evaluation meeting

Tables 5-3 and 5-4 show the results of questions Q1 and Q2, respectively.

Based on the questionnaire results, the students regarded “Outline of IFRM,” “Concept of IFRM,” “Effect of Climate Change,” “Human Action and Social Psychology,” and “River Channel Planning” as most useful for flood mitigation in their countries. Because they have already been involved in the water-related sector for some time back in their home countries, the lectures on IFRM especially gave them a perspective to take a fresh look at water issues.

The lecturers were generally rated highly by the students. Among the most highly rated were Prof. Tadaharu Ishikawa (Tokyo Institute of Technology), Prof. Shoji Fukuoka (Chuo University), Prof. Taikan Oki (Tokyo University), Prof. Haruo Hayashi (Kyoto University), Prof. Mikiyasu Nakayama (Tokyo University), Prof. Frank Meulen (UNESCO-IHE). They all happened to be university

professors, indicating that they were well experienced and skilled at keeping the students' attention to the class in addition to the excellent content of their lectures.

Table 5-3 Top Three lectures that the students regarded useful for their countries
(Dam Engineering and Sabo Engineering are excluded)

Student No.	First	Second	Third
1	River Channel Planning	Outline of IFRM	Flood forecasting, Kalman filter
2	Effect of Climate Change	Concept of IFRM	Hydraulics
3	Outline of non-structural measure and community defense	Town watching (1), (2)	Inundation analysis (1), (2)
4	River Channel Planning	Effect of Climate Change	Concept of IFRM
5	Human action and social psychology	Outline of IFRM	Town watching
6	River Channel Planning	Concept of IFRM	Remote sensing
7	Flood plain management	Comprehensive sediment-related disaster measures	Human action and social psychology
8	Hydraulics	Hydrology	IFRM
9	Hydrology	Hydraulics	IFRM(River design)
10	Human action and social psychology	Effect of Climate Change	Flood insurance

(No. of respondents: 10)

Table 5-4 Top five lecturers (excluding ICHARM staff)

Student No.	First	Second	Third	Fourth	Fifth
1	Prof. Watanabe (CERl)	Prof. T. Ishikawa (Tokyo Institute of Technology)	Prof. Oki (Tokyo Univ.)	Prof. Fukuoka (Chuo Univ.)	Prof. Meulen (UNESCO-IHE)
2	Prof. Oki (Tokyo Univ.)	Prof. Meulen (UNESCO-IHE)	Prof. Watanabe (CERl)	Ms. Mandira Shrestha (Nepal)	
3	Prof. Oki (Tokyo Univ.)	Prof. Fukuoka (Chuo Univ.)	Prof. Ogawa (Fuji-tokoha Univ.)	Prof. T. Ishikawa (Tokyo Institute of Technology)	Prof. Hayashi (Kyoto Univ.)
4	Prof. Watanabe (CERl)	Prof. T. Ishikawa (Tokyo Institute of Technology)	Prof. Oki (Tokyo Univ.)		
5	Prof. Hayashi (Kyoto Univ.)	Prof. Oki (Tokyo Univ.)	Prof. Ogawa (Fuji-tokoha Univ.)	Prof. Nakayama (Tokyo Univ.)	Prof. Meulen (UNESCO-IHE)
6	Dr. Watanabe (CERl)	Prof. T. Ishikawa (Tokyo Institute of Technology)	Prof. Fukuoka (Chuo Univ.)	Prof. Oki (Tokyo Univ.)	Prof. Meulen (UNESCO-IHE)
7	Prof. Nakamura (Tokyo Univ.)	Prof. Oki (Tokyo Univ.)	Prof. Hayashi (Kyoto Univ.)	Prof. Okubo (Japan Sabo Association)	
8	Prof. Oki (Tokyo Univ.)	Prof. T. Ishikawa (Tokyo Institute of Technology)	Prof. Watanabe (CERl)		
9	Prof. T. Ishikawa (Tokyo Institute of Technology)	Prof. Fukuoka (Chuo Univ.)	Prof. Oki (Tokyo Univ.)	Prof. Meulen (UNESCO-IHE)	Prof. Watanabe (CERl)
10	Prof. Fukuoka (Chuo Univ.)	Prof. Nakayama (Tokyo Univ.)	Prof. Watanabe (CERl)	Prof. T. Ishikawa (Tokyo Institute of Technology)	

(No. of respondents: 10)

Lectures by Professors Hayashi and Nakayama must have been particularly impressive on the students, considering they each had only one lecture during the training. Prof. Watanabe (Kitami Institute of Technology), a former senior researcher of the Civil Engineering Research Institute for Cold Region of PWRI, was also highly rated, which suggests that River Engineering was well received by the students. Prof. Meulen was with the students in the Ise field trip for four days including the Town Watching exercise, giving helpful advice to them. That too probably helped his high evaluation by the students.

5.1.2.2 Results of the third evaluation meeting

Tables 5-5 and 5-6 show the results of question Q1 and Q2, respectively.

According to Table 5-5, the following three were highly evaluated by the students: “Effective use of the existing dams” by Mr. Norihisa Matsumoto (an advisor of the Japan Dam Engineering Center), “Impacts of dams on the environment (1)” by Mr. Kunihiro Amano (a team leader of PWRI), and “Impacts of dams on the environment (2)” and “Sediment control in reservoirs” by Ass. Prof. Tetsuya Sumi (Kyoto University).

It was interesting that the students regarded lectures on the impacts of dams on the environment as more useful for their countries than those on dam engineering. It implies that even developing countries cannot afford to ignore the social and environmental impacts of dams anymore.

Based on the results shown in Table 5-6, the following three were highly regarded by the students: “Sabo in arid regions and forestation of devastated land” by Dr. Hiroshi Ikeya (the chief executive of the Sabo Technical Center), “Landslide survey and emergency response measures” by Dr. Kazunori Fujisawa (a team leader of PWRI), and “Landslide characteristics and topography” by Ms. Mio Kasai (a researcher of PWRI). Dr. Ikeya's lecture covered an issue in a different climatic region rather than the Asia Monsoon, which may have attracted the students' attention. Dr. Fujisawa and Ms. Kasai explained the fundamentals of landslides in an easy-to-understand manner.

Table 5-5 Top three lectures regarded as useful for the students' countries
among the "Dam Engineering" lectures

Students No.	First		Second		Third	
1	Environmental impact of dams (2)	Ass. Prof. Sumi (Kyoto Univ.)	Practice of dam design	Mr. Sakurai (PWRI)	Dam construction	Prof. Yamaguchi (PWRI)
2	Practice of dam design		Dam construction			
3	Environmental impact of dams (1)	Dr. Amano (PWRI)	Sediment Management in Reservoirs	Ass. Prof. Sumi (Kyoto Univ.)		
4	Environmental impact of dams		Effective use of existing dams	Prof. Matsumoto (Japan Dam Engineering Center)	Sediment Management in Reservoirs	Ass. Prof. Sumi (Kyoto Univ.)
5	Sediment Management in Reservoirs (1)	Ass. Prof. Sumi (Kyoto Univ.)	Environmental impact of dams (1)	Dr. Amano (PWRI)		
6	Effective use of existing dams	Prof. Matsumoto (Japan Dam Engineering Center)	Environmental impact of dams (1)	Dr. Amano (PWRI)		
7		Prof. Matsumoto (Japan Dam Engineering Center)		Ass. Prof. Sumi (Kyoto Univ.)		Mr. Umino (PWRI)
8	Dam Management	Prof. Yamaguchi (PWRI)	Effective use of existing dams	Prof. Matsumoto (Japan Dam Engineering Center)	Sediment Management in Reservoirs (1)	Ass. Prof. Sumi (Kyoto Univ.)

(No. of respondents: 8)

Table 5-6 Top three lectures regarded as useful for the students' countries
among the "Sabo Engineering" lectures

Student No.	First		Second		Third	
1	Application of Sabo	Dr. Ikeya (STC)	Maintainance measures	Dr. Fujisawa (PWR)	Characteristics and topography of landslides	Ms. Kasai (PWR)
2	Characteristics and topography of landslides	Ms. Kasai (PWR)	Sabo works in arid area and reforestation	Dr. Ikeya (STC)		
3	Permanent measures for landslid damage reduction	Mr. Ishida (PWR)	Application of Sabo works and landslide countermeasures	Mr. Watanabe		
4	Characteristics and topography of landslides	Ms. Kasai (PWR)	Survey and emergency response for landslide	Dr. Fujisawa (PWR)		
5	Characteristics and topography of landslides	Ms. Kasai (PWR)	Survey and emergency response for landslide	Dr. Fujisawa (PWR)		
6	Sabo works in arid area and reforestation	Dr. Ikeya (STC)	Survey and emergency response for landslide	Dr. Fujisawa (PWR)	Characteristics and topography of landslides	Ms. Kasai (PWR)
7		Dr. Fujisawa (PWR)	Application of Sabo works and landslide countermeasures	Mr. Watanabe	Sabo works in arid area and reforestation	Dr. Ikeya (STC)
8	Survey and emergency response for landslide	Dr. Fujisawa (PWR)	Characteristics and topography of landslides	Ms. Kasai (PWR)	Sabo works in arid area and reforestation	Dr. Ikeya (STC)

(No. of respondents: 8)

5.1.3 Evaluation on the field trips

At the final evaluation meeting, the students were asked about which field-trip destination was the most impressive among those listed in Table 2-3. They chose the Ohta river, Disaster Reduction and Human Renovation Institution, Kanda River Underground Regulating Pond, Watarase Retarding Basin, Tateyama Sabo Project, and Isawa Dam.

In the field trips, the students had several opportunities to visit famous tourist spots. Although those spots were not directly related to water issues, they were taken there because it was considered to be important to learn a cultural aspect of Japan. Among the spots, they chose the Atomic Bomb Dome in Hiroshima as the most impressive, followed by Ise Shrine and Edo Tokyo Museum.

In November 2007, the students took a trip to Ise City and stayed at a Japanese traditional-style inn for three days, and they were very pleased with such a rare occasion.

The evaluation results should be utilized as much as possible to plan and execute efficient, effective field trips from the next year on.

5.1.4 Evaluation on the whole training course by the students

At the end of the training course, the students were asked to complete questionnaires prepared by ICHARM and JICA Tsukuba to collect feedbacks on the course.

5.1.4.1 Results of the questionnaire by ICHARM

Six questions listed in the table below were asked in the ICHARM questionnaire. They were mainly intended to ask about how to work on their Master's theses and how to implement their action plans in their home countries.

The students' answers on Master's theses are as follows:

- It was difficult to collect necessary data for the theses.
- There should be a presentation opportunity on the theses halfway before the completion. (The number of presentations in the first half needs to be reduced.)
- More time should be allocated to independent study by reducing the number of lectures.
- It is true that discussions are possible among the students outside the class, but we need more structured discussions within a designated time frame.

These feedbacks will be reflected in the next year's training course as much as possible.

On the implementation of their action plans in their countries, the students did not have any clear idea of how they could actually implement the plans they developed in the training course. Answering the questionnaire, all they could say was that the first thing they could do in their home countries would be to share knowledge they learned in Japan with their supervisors and colleagues or that they

would ask JICA for assistance in the implementation of the plan. Constant follow-up efforts will be necessary to provide some kind of support for them in local activities, for example, by asking the degree of progress through e-mail or other means once every few months or paying additional visits to them on the occasion of international business trips.

Other comments suggested that more textbooks were necessary and that there should be fewer lecturers by assigning more lectures per person.

Table 5-7 Results of the questionnaire by ICHARM

Q1. What was the most impressive/helpful/insightful lecture for you? And why?	● Lecture about risk, vulnerability and hazard ● Hydrological observation, Modeling & Forecasting. ● Lectures of Dams. They showed some new method how to communicate with common people or how to evaluate the effectiveness of dams using special questionnaire.
Q2. Who is the most impressive lecturer for you? And why?	● Prof. Takeuchi. He can make the class room comfortable to understand. ● Prof. Ishikawa. His lecture is easy to understand and interesting. ● There is no doubt Prof. Takeuchi is the best lecturer. ● Dr Osti is the most impressive lecturer. His lecture and practice is much practical and he always supported us even if he was busy.
Q3. What do you think about the course schedule and guidance (content and method) you were given to plan and write your Master's thesis?	● Everything was ok. But after completion of theory class study area visit is essential to get detailed information ● Course schedule is very tight and not sufficient. In order to perform good research, more time than scheduled is needed. ● We should have an opportunity at least once during our study of our thesis. ● Knowledge of computer program like FORTRAN, VISUAL BASIC is required for individual study. ● The total period of this course is just good in 1 year.
Q4. What did you learn in this course that you can share with your colleagues and bosses?	● I learned how Japanese overcome from past flood situation by integrated flood management. ● Most important achievement is I could realize our weakness on disaster management. So, I would like to start sharing of my learning's form our weakness.
Q5. List problems you would face and support you would need when implementing your action plan back in your country.	● Still I am not sure what kind of problem will have to face in my country to implement this project. After discussion with my department, I will get idea about the implementing problems and then I can ask help from JICA. ● First of all we need to strengthen our self economically. How the economical strengthening of the country goes? Implementation of such action plan depends on that.

	● As a young man, I cannot manage such a big project. So I need some experts or supervisor to help me to implement this action plan.
Q6. Please write suggestions to improve this course.	● The duration should be 1 year 6 months and after completion of theory class 1 site visit is essential. More text book should supply with lecture material. ● For Master's Degree, design period is shorter so it's better to extend it. Most of the class lectures are in presentation format and study materials are not sufficient. ● We can discuss in the class room but it is better to set "discussion time" so that we can improve our thesis with some pressure. ● We did several presentations on our individual study in the early stage of our study. That can be reduced and can be done after some progress on it. ● I think ICHARM has many research projects, so maybe it's easier to let us join you than let us to find a new topic. In my case, I spend about first four months to choose a research topic. We are paid by our government and JICA, ICHARM can use us freely. In that way, we can begin our individual study early and can have many concrete and deep discuss with ICHARM staffs and can learn much more. ● More textbooks are required for Master's course. ● During the last 4 month, there should be some interim presentations for showing our progress on thesis. ● I feel that volume of lectures should be reduced. One subject lecture series should be conducted by one lecturer as much as possible.

5.1.4.2 Results of the questionnaire by JICA Tsukuba

The following outlines the results of the questionnaire administered by JICA Tsukuba.

1. Suitability of the goals with the actual needs

Most of the respondents answered that the training goals were set appropriately to meet the actual needs. (Five points --- one respondent, four points --- five respondents)

2. Evaluation of the training curriculum

"Integrated Flood Risk Management (IFRM)" and "Hazard Mapping & Evacuation Planning" were evaluated to be the best lectures along with a few others.

The students suggested a few lectures to be added to the curriculum, such as ones about landslide-related issues, ones that require mathematical application, computer languages like

FORTRAN and Visual Basic, and Arc-GIS.

3. Length of the training

Many of the students considered that 12 months was sufficient as the length of the training period, while a few said that being a Master's course, the training should be 18 months. Many preferred 12 months probably because the students all had a job back home and it must have been difficult to take a long leave from work.

4. Presentation of lecture materials & 5. Textbooks and educational equipment/facilities

Most of the students gave four points on these points (4 & 5). Many lecturers used Power Point for their lectures, but for the students to easily review the lecture contents afterwards, requests should be continuously made for lecturers to produce textbooks.

This training course employed most of the exercise instructors from ICHARM staff to provide the students with substantial, detailed training. As intended, all the exercise classes were highly rated by the students. However, many of them commented that more time should be allocated to exercises.

6. Management of the training course

Many of the students made favorable remarks on the management of the training course. That was probably because several interim evaluation meetings were held during the training in the effort of accommodating their needs and requests.

7. Satisfaction to their expectations

Most of the students were satisfied (four students) or highly satisfied (two students) with the training course, thinking that the course met their expectations. However, they also commented that lecture contents should be more advanced and more assignment should be given.

8. Self-rated achievement level by goal

		high	(Self-rated achievement level)				low
		5	4	3	2	1	
Achievement goal 1	Before training			4	2		
	After training	1	5				
Achievement goal 2	Before training			6			
	After training		6				
Achievement goal 3	Before training			4	2		

	After training		6			
Achievement goal 4	Before training		1		1	
	After training		2			
Achievement goal 5	Before training			4	2	
	After training	1	5			

Students' comments on Achievement Goal 1:

- In Bangladesh, we have mostly employed structural measures. In the training, I have learned some new concepts like flood hazard mapping. Now I can do my job using both structural and non-structural measures.
- As an engineer, I am looking forward to using the knowledge of integrated flood risk management, which is a new and important concept for the management of the Yangtze river basin.

Students' comments on Achievement Goal 2:

- The disaster risk management policy and a method to promote residents-based risk management can be effectively applied to many areas in Nepal.
- The knowledge I have learned this time will be helpful to develop public policies to reduce flood risk in Bangladesh and plan risk management systems.

Students' comments on Achievement Goal 3

- Emergency response measures I learned can be applicable to my country (India and China).

Students' comments on Achievement Goal 4:

- Disaster risk management should be considered as essential part of development, and the Nepalese government should invest in it.
- I would like to make a proposal on the management of the Yangtze River to the leaders of our country if given a chance.

Students' comments on Achievement Goal 5:

- What I learned here will help me a lot in the development of efficient risk management strategies.
- I would like to share my thoughts with the people in the management section.

5.2 Issues for future improvement

5.2.1 Evaluation of the students' achievement of the course content

Just like in other training courses, the knowledge level of the students varied widely in this course, causing some problems as they proceeded with lectures and exercises. With support from the course lecturers and ICHARM staff, each student was able to set his/her own theme for the Master's thesis, which would help solve problems that he/she was facing. They all submitted the theses, met the graduating requirements, and earned a Master's degree in disaster management.

Table 5-8 shows achievement goals, lectures conducted based on each goal, achievement criteria, and the course evaluation by the course organizers.

The students were given written exams after each lectures to objectively evaluate the students' achievement levels. To evaluate their achievement from multi-perspectives, class contribution and motivation for exercises were also taken into consideration. As a result, most of the students reached the required achievement level set for each goal.

Table 5-8 Evaluation of the students' achievement of the course content

Achievement goals	Lectures	Criteria	Achievement level
1) To learn recent approaches employed across the world in integrated flood risk management	○ IFRM(1) Basic Concepts of IRBM, IFRM & Global Trends	Class contribution, written exam	All the students demonstrated a general understanding of integrated flood risk management through the lectures and class discussions.
2) To become able to clarify what is necessary to effectively reduce flood risk at the local and national levels, including public policies. Also, to become able to plan a risk management system at the local and national levels as well as develop a management system which includes various stakeholders and cooperation among organizations.	○ IFRM(2) Non-structural Measures & Community Defense ○ Hazard Mapping & Evacuation Planning	Contribution to the Town Watching exercise, written exam	All the students came to understand the importance of risk reduction by means of flood hazard maps through the Town Watching exercise and interviews with residents in Ise City. They also learned the administrative and legal systems in Japan for risk management through the lectures.

3) To become able to develop indices at the local and national levels to detect and monitor changes in emergency response and disaster risk reduction as well as to become able to monitor the status and impacts of such policies using the indices.	○ Hydrological Observation, Modeling & Forecasting ○ Hydraulics ○ IFRM(3) IRBM & Structural Measures ○ Sustainable Reservoir Development & Management ○ Control Measures for Landslide & Debris Flow	Report, written exam	All the students understood the importance of fundamentals necessary for flood control, such as basic knowledge in hydrology and hydraulics, major flood control structures (e.g. dams and levees), and sabo projects, through the lectures, exercises, and field trips. This understanding will help the students develop indices to detect and monitor changes in emergency response and disaster risk reduction.
4) To become able to contribute to the implementation of plans developed based on integrated risk management policies which are formulated in clearly-defined financial, institutional and legal frameworks.	Master's thesis	Completion of a Master's thesis	All the students identified flood-related problems in their home countries, studied possible strategies to solve them, and completed their Master's theses.
5) To become able to develop a risk management strategy which incorporates major critical management factors, such as emergency response, restoration, mitigation and preparedness. The strategy should also pay due consideration to issues in risk detection and information dissemination, as well as emerging threats, such as global warming and climate change.	○ IFRM(1) Basic Concepts of IRBM, IFRM & Global Trends ○ IFRM(2) Non-structural Measures & Community Defense ○ IFRM(3) IRBM & Structural Measures	Written exam	All the students learned to independently develop a risk management strategy based on knowledge and technologies they had learned through the lectures, exercises, field trips, and thesis writing during the one-year Master's course.

5.2.2 Overall evaluation of the training course and issues for improvement

This training course was the first long-term Master's level course that ICHARM ever planned and managed. The course management was however successful despite the initial worries we had had because of the length and level of the training. There is no doubt that the entire experience from preparation to actual operation of the project will be a great asset for future training activities at ICHARM.

The following are points taken notice of in the process of planning and managing this training course. Improvement should be made to as many of those points as possible for the next year's training course.

<Lecturers>

As in the results of the students' evaluation on the lectures shown in 5.1.2, most of the lectures regarded as easy-to-understand, impressive and useful were conducted by university professors. Those highly rated lecturers shared something in common. They all lectured as if they were talking to each of the students. They lectured not at their own pace but at the students' pace. When using Power Point slides, they spent quite a long time explaining each slide. Meanwhile, lecturers who were not so highly rated used a lot of Power Point slides and did not always look at the students while talking. Next year, lecturers should be advised on those points for better lectures.

<Lectures>

IFRM (1) and (2) were taught by many lecturers because the subject actually had to cover a lot of contents in the field. It is not necessarily a bad idea to split a single subject between two under certain conditions such as this. In this case, however, a single lecturer should have some classes because the students would have become more used to the lecturer and would have had more chances to ask questions. This style may have been advantageous for the lecturer, too. He could have been able to adjust the course contents to the students' level to teach more efficiently from the second class on.

<Joint class with the students in the Flood Hazard Mapping training course>

The Master's course shared the series of classes on "Hazard Mapping & Evacuation Planning" with the Flood Hazard Mapping training course conducted in November, 2007. The students in those two courses jointly participated in lectures, exercises and field trips arranged to learn flood hazard mapping. There were 30 students in total from 13 most flood-prone countries in Asia, including Bangladesh, Cambodia, China, India, Indonesia, Lao DPR, Malaysia, Nepal, the Philippines, Thailand, Sri Lanka, Vietnam and Japan (Figure 5-1).

This wide variety of the students provided global perspectives to the training and contributed to active discussions and exercises. Also, it facilitated more interaction among the students. On the other hand, 30 students were sometimes too many for an instructor to handle, especially, while doing exercises, but in such cases, an additional instructor from ICHARM was assigned to help the original one.

For the training course next year, collaboration with other training courses will be further promoted.

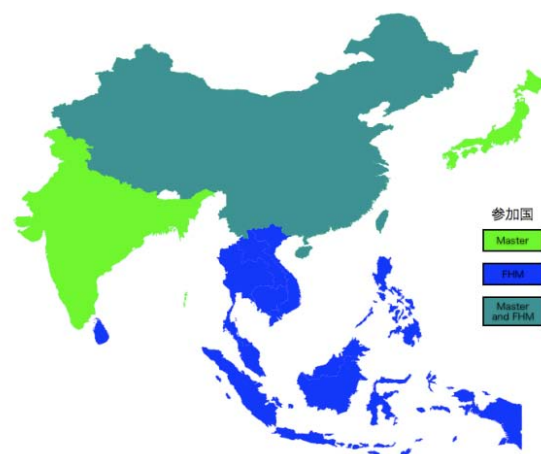


Figure 5-1 Home countries of the trainees in the Master's course and the Flood Hazard Mapping training course

<Improvement for better thesis writing>

JICA Tsukuba provided short-term Japanese language classes for the students after they came back from the training at ICHARM. Many of the students, however, also needed to work on their English skills because English is not their native language. In particular, to improve their thesis writing skills in English, short-term, intensive English training should also be provided.

In addition, they often needed to be taught basic computer skills necessary for thesis writing, for example, how to use MS Word and Excel. Students in general need to know useful functions, for instance, to set a document style and automatically create a table of content. They should also learn how to sort data and use functions for computation using Excel. Furthermore, they should become familiar with all those basic computer skills by March, when they are scheduled to start writing their theses.

<Procedures for thesis writing>

In the first year, the students had to decide themes for their Master's theses around the time when they were just finishing the Flood Hazard Mapping training. Because of that, they tended to choose their themes from issues related to flood hazard mapping.

Although there are highly-trained foreign researchers at ICHARM, the students could not make full use of the expertise of those researchers because collaboration between the researchers' expertise and the students' theses was not actively promoted until later. They should have started working on the

theses much earlier under the supervision of the researchers.

In the process of thesis writing, some of the students had trouble collecting necessary data from their affiliations due to lack of cooperation and communication. How to promote a sense of ownership not only in students but also in their affiliation is an important issue.

Additionally, there was no opportunity to make a presentation on their Master's theses after April in the first year of this training course. That was probably one reason why the students lacked a sense of urgency toward the completion of their theses. A mid-term presentation should be arranged around late May to provide an opportunity for students to confirm how much they have done by then. This has already been scheduled in the new curriculum for the training course next year. To further motivate students for thesis writing, efforts are being made to provide students with an opportunity to present their theses at a conference in Japan.

<Field trips>

Field trips are very important learning opportunities for students to take a close look at flood control strategies in Japan. They should be arranged in the first half of the training course if possible because they help students create concrete images of what lectures and exercises are about. On the other hand, such trips can also be refreshing during thesis writing. Thus, the timing of field trips should be determined examining the annual schedule from those multiple viewpoints. In the first year of the Master's course, they were mostly arranged around April. Next year, they are mostly arranged in the first half depending on the lecture schedule.

Field trip schedule: 2007-2008	November, March, April, May, September
2008-2009 (tentative)	October, November, December, March, May

The students were assigned to study trip destinations beforehand and submit a report after each trip to emphasize that the trips were planned for learning not just for pleasure. The assignment was given also to help them improve their English writing skills. Furthermore, to learn a Japanese way of expressing gratitude in an official setting, the students took turns thanking those who provided learning experience at each trip destination.

<Action plans>

There was not enough time to spend in developing action plans because the students started working on them after submitting their Master's theses with not many days left before departing for their

home countries. More time should be allocated for the development of action plans by setting the due date for Master's theses earlier.

In addition, to make action plans more practical for implementation, students should be required to communicate with their affiliations on the matter in the process of developing the plans.

<Communication between leaving and coming students>

This Master's training course ends in September every year. New students will have been selected by that time. To help new students collect necessary data for their theses without difficulty, leaving students should be strongly encouraged to get in touch with their new counterparts before they leave Japan.

<Follow-up activities after completing the training>

The goal of this Master's training course is to produce experts with skills to cope with social needs so that they can demonstrate the importance of disaster management at the nation level to policy makers. However, this can not be realized in a short period of time. Constant follow-up activities are necessary even after students go back to their home countries.

<Joint follow-up seminar with the former students of the Flood Hazard Mapping training course>

As described earlier, the students in the Master's course had jointly participated in lectures and exercises with those in the Flood Hazard Mapping training course. Considering that flood hazard mapping, including its resultant products, is an important tool for risk management, the graduates of the Master's course should also be invited to follow-up seminars for ex-students in the Flood Hazard Mapping training course to share useful information with other experts.

<Use of training course videos>

Almost all the lectures conducted in the Master's course were videotaped. The videotapes can be a precious resource for future training because the lecture contents are useful not only for students in this course but also other students and the general public. Due consideration should be given to the future use of the lecture record, including the possibility of e-learning.

Chapter 6 : Field trips to Nepal, Bangladesh and India by ICHARM

6.1 Purposes

In February 2008, ICHARM sent a field trip team to Nepal, Bangladesh and India, which were target countries of this Master's training course.

There were two principal purposes for these field trips. One of them was to visit and request those target countries to send capable students to the Master's course next year. The team visited directors and other important individuals at the affiliations of the students and JICA local offices, and explained about academic skills, requirements and eligibility required of students to successfully complete the training course. Also, the team thanked them for sending the students to the first-year training course.

The other purpose was to identify and analyze problems the three countries were facing. Due to climate change caused by global warming, there have been an increasing number of extreme events in the region where the three countries are located. For example, glacial lake outburst floods (GLOF) in Nepal and sea level rise in Bangladesh. The field trip team studied flood damage by local rivers, strategies for water disaster prevention, flood damage mitigation, and other issues. Through the field trips, ICHARM staff had an excellent chance to take a close look at areas and basins on which the students put focus for their thesis. This helped the staff supervise the students in writing the Master's thesis and contributed to the improvement of the course curriculum from the next year on.

The trips were actually planned to have meetings with the directors of the students' affiliations to share achievement goals, the final goal of this Master's course after three years, and expected results, and then to decide the common training goals between the affiliations and ICHARM. Unfortunately, it was not possible this time.

6.2 Itinerary

The field trips were scheduled from February 2 to 13 in 2008. During the trips, the trip team visited the affiliations of the students and several research institutes to seek for possible research and training collaboration between ICAHRM and those organizations.

[Nepal]

- JICA Nepal Office
- Department of Water Induced Disaster Prevention(DWIDP), Ministry of Water Resources
(one of the students' affiliations)

- International Center for Integrated Mountain Development (ICIMOD)
- Nepal Development Research Institute (NDRI)
- Tribuvan University
- Department of Hydrology & Meteorology (DHM), Ministry of Environment Science & Technology

[Bangladesh]

- JICA Bangladesh Office
- Bangladesh Water Development Board (BWDB) (one of the students' affiliations)
- Center for Environmental and Geographic Information Service (CEGIS)

[India]

- JICA India Office
- Water Resources Department, Bihar State Government
- Central water Commission (CWC), Ministry of Water Resources (in charge of selecting students for ICHARM's training course)
- Indian Institute of Technology (IIT)

The field trips also included research on actual local situations especially in terms of rivers, flood damage, flood disaster mitigation in each country. For example, the team visited glacial lakes and the upper reach of the Bagmati River in Nepal. They also observed the erosion along the Jamuna River in Bangladesh, flood control in Dhaka, the Ganges River and the lower reach of the Bagmati River in India.

Table 6-1 shows the itinerary of the field trips, and Figure 6-1 shows the locations of the trip destinations.

Table 6-1 Itinerary of the field trips

	Date	Destination and purpose	Hotel, etc.
1	Sat. Feb. 2	10:55 Narita → 16:00 Bangkok JL 717	Bangkok (Novotel Suvarnabhumi Airport)
2	Sun. Feb. 3	10:45 Bangkok → 13:00 Kathmandu TG319 14:30 Department of Water Induced Disaster Prevention (DWIDP)	Kathmandu (Hotel Sunset View)
3	Mon. Feb. 4	7:30-12:30 Research at glacial lakes (Imja, Rolpa, Sabai) with ICIMOD 14:00-17:00 ICIMOD	Kathmandu (Hotel Sunset View)
4	Tue. Feb. 5	10:00 NDRI 11:30 Tribuvan University 13:00 ICIMOD 16:30 JICA Nepal Office	Kathmandu (Hotel Sunset View)
5	Wed. Feb. 6	A.M. Research in the Kathmandu area with DWIDP P.M. Department of Hydrology & Meteorology (DHM) 15:50 Kathmandu → 17:20 Dhaka BG704	Dhaka (Washington Hotel)
6	Thur Feb. 7	9:00 JICA Bangladesh Office 11:00-12:30 Bangladesh Water Development Board (BWDB) 13:30-14:40 CEGIS	Bogra (Parjaton Bogra)
7	Fri. Feb. 8	10:00-14:00 Research in the Bogra area with Mr. Khandakar (BWDB) and Mr. Arefin (JICA Office)	Dhaka (Washington Hotel)
8	Sat. Feb. 9	10:30-17:00 Research in the Dhaka area with Mr. Khandakar (BWDB) and Mr. Arefin (JICA Office) 19:00- Dinner at Mr. Khandakar	Dhaka (Washington Hotel)
9	Sun. Feb. 10	9:15 Dhaka → 11:05 Delhi 9W271 15:25 Delhi → 18:00 Patna S2171 (domestic)	Patna (Hotel Mautya)
10	Mon. Feb. 11	All day Research along the Ganges River 21:30 Patna → 23:00 Delhi 9W728 (domestic)	Delhi (Ikon Residency)
11	Tue. Feb. 12	9:00 JICA India Office 10:00 IIT 13:00 Ministry of Water Resources 19:50 Delhi → 6 : 45 (2/13) Narita JL472	(overnight flight)

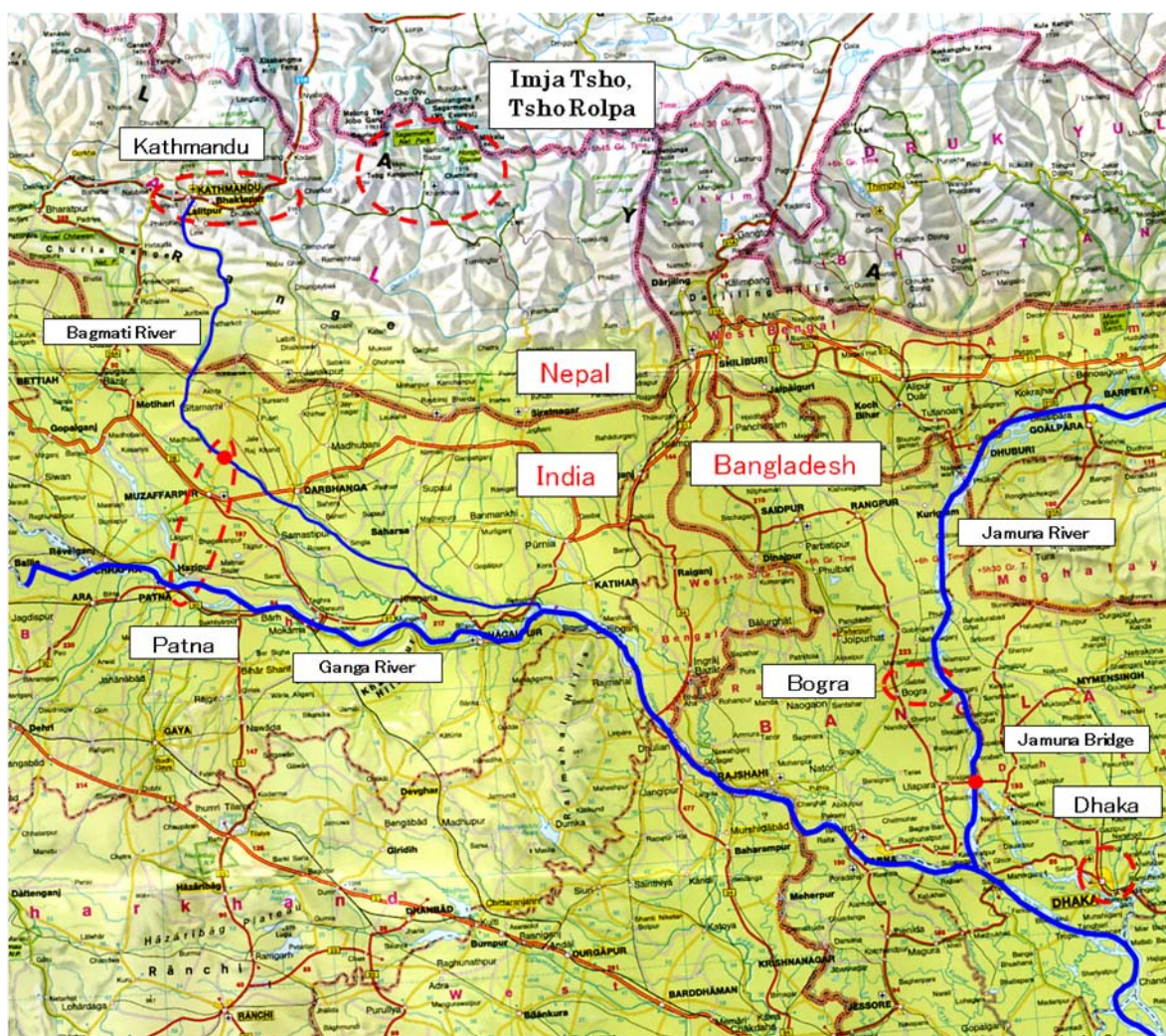


Figure 6-1 Locations of the field trip destinations

6.3 Field trip participants

The following table 6-2 shows the information of the field trip participants.

Table 6-2 Participants List

Responsibility	Name	Affiliation and position
Leader	Kuniyoshi Takeuchi	ICHARM, Director
Disaster prevention	Shigenobu Tanaka	ICHARM, Team Leader
River engineering	Daisuke Kuribayashi	ICHARM, Researcher
Training planning	Akihiro Matsumoto	JICA Tsukuba, Senior Training and Partnership Program Officer

(The affiliations and positions are at the time of the trip.)

6.4 Outline and results of the field trips

6.4.1 Nepal



Figure 6-2 Kathmandu City

[February 3]

The first destination in Nepal after the arrival at Kathmandu was the Department of Water Induced Disaster Prevention (DWIDP), which had sent students to the ICHARM Master's training course.

Accompanied by Mr. Hitoshi Kato, a JICA advisor for disaster prevention who was sent to Nepal from the Sabo Division of the River Bureau, MLIT of Japan, the field trip team visited Mr. Narayan Prasad Bhattarai, director of DWIDP, and Mr. Naveen M. Joshi, senior engineer in water resources. They were able to get the latest information on Glacial Lake Outburst Floods (GLOF) and also requested the department to send students for the Master's training course the next year.



Photo 6-1 Headquarters of DWIDP



Photo 6-2 Presentation by Mr. Naveen M. Joshi

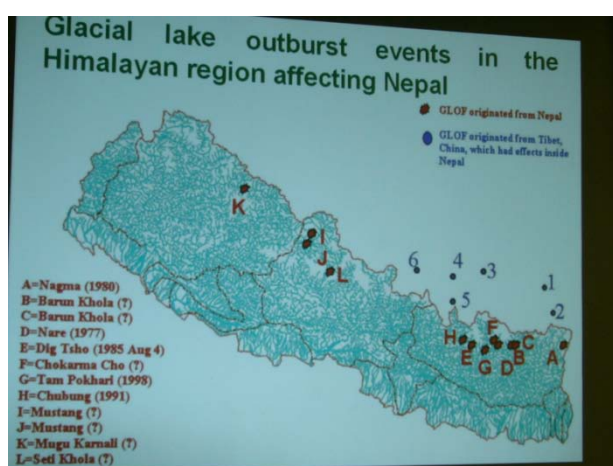


Photo 6-3 Current status of GLOF in Nepal

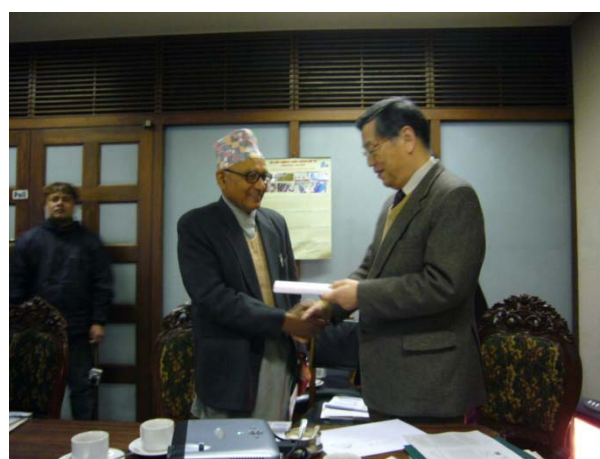


Photo 6-4 ICHARM Director Takeuchi thanks DWIDP Director Narayan Prasad Bhattarai.

[February 4]

In the morning, the trip team took a helicopter ride to observe three glacial lakes from the air via the route shown in blue with the staff from the International Center for Integrated Mountain Development (ICIMOD).

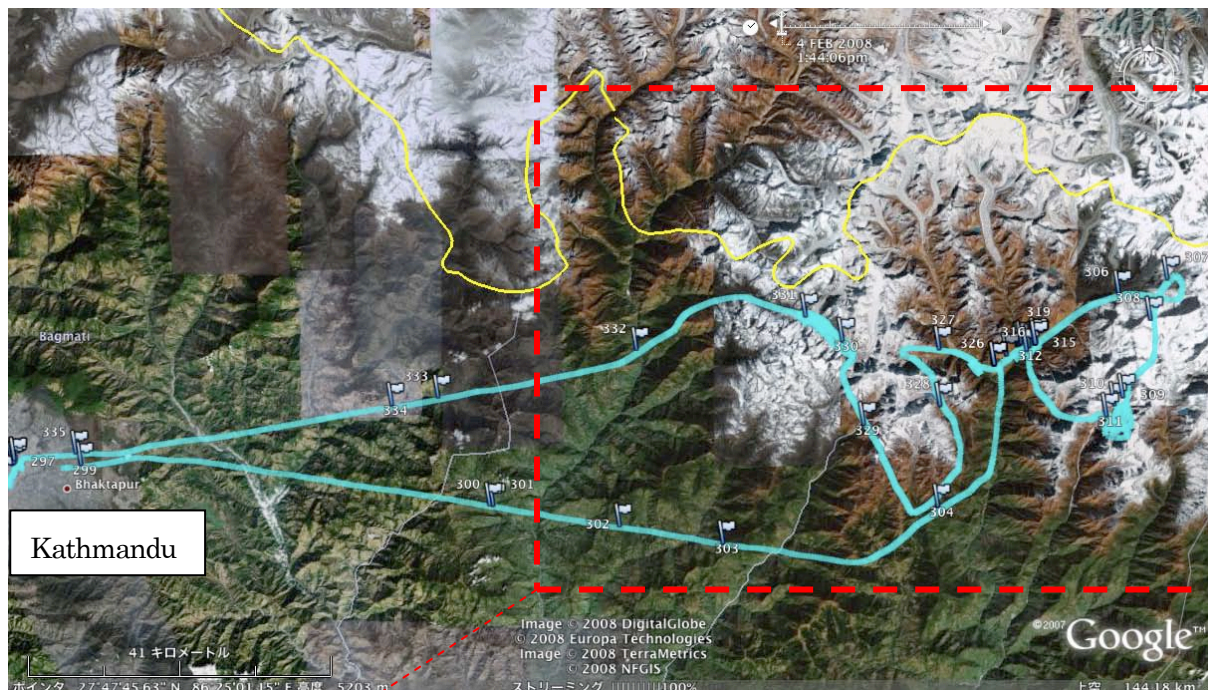


Photo 6-5,6 Helicopter route for the glacial lake observation in Nepal
(above: overall view; below: detailed view)

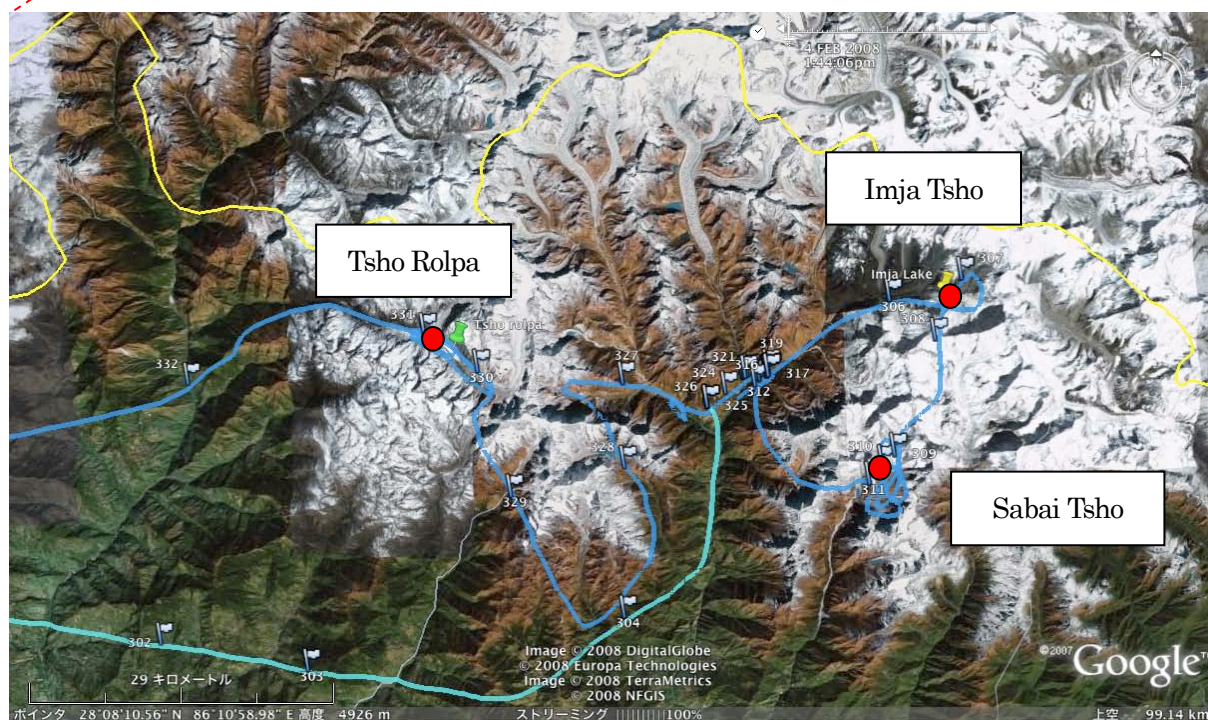




Photo 6-7 Participants in the helicopter observation



Photo 6-8 Mountains viewed from the plane leaving Katmandu for the next destination. It seems that development has reached their top.



Photo 6-9 The helicopter took a short rest here on the way to the glacial lakes (elevation: 3.700 km).



Photo 6-10 Mt. Everest



Photo 6-11 Imja Tsho (glacial lake)



Photo 6-12 Tsho Rolpa (glacial lake)

In the afternoon, the team visited ICIMOD, where they were provided with detailed information about ICIMOD and exchanged opinions and ideas for future research collaboration.



Photo 6-13 Headquarters of ICIMOD



Photo 6-14 ICHARM Director Takeuchi discusses with ICIMOD Director Andreas Schild.



Photo 6-15,6 ICHARM exchanges opinions and ideas with researchers at ICIMOD.

[February 5]

The field trip team visited a few more places to meet researchers and exchange ideas. The first destination on the day was the Nepal Development Research Institute (NDRI), which is one of the current partners in ongoing research activities at ICHARM. Director Nawa Raj and staff researchers made presentations on their research projects. Also, the team visited Professor Narendra Man Shakya at Tribuvan University.

In the afternoon, the team visited ICIMOD again and continued discussing various issues as they did on the previous day.

In the early evening, the team also visited the JICA Nepal Office to meet Director Noriaki Niwa, Vice Director Yoshio Fukuda, JICA Officers Yusuke Tsumori and Sourab Rana. The meeting was very informative, covering various issues from social conditions in Nepal to flood control.



Photo 6-17 ICHARM staff discusses with NDRI Director Nawa Raj.



Photo 6-18 ICHARM staff visits Professor Narendra Man Shakya at Tribuvan University.



Photo 6-19 Meeting at JICA Nepal Office

[February 6]

The morning was spent visiting the Bagmati River and its tributaries in the southern suburb of Kathmandu. The team found that the water quality of those rivers was not good and some parts of the embankments were destroyed and no longer effective in flood control. They also had an opportunity to see a sabo project which is currently in progress with financial aid from Japan.

In the afternoon, the team visited Mr. Keshav P. Sharman, vice director of the Department of Hydrology and Meteorology (DHM) of the Ministry of Environment Science and Technology.



Photo 6-20,21,22,23 Views seen from a bridge over the Bagmati River
(left [upstream] : houses in a flood plane, right [downstream]: destroyed wier)



A sabo wall built with financial aid from Japan



Southern suburb of Katmandu



Photo 6-24 ICHARM staff discuss with Mr. Keshav P.Sharma of DHM

6.4.2 Bangladesh

[February 7]

The field trip team first visited the JICA Bangladesh Office in Dhaka to meet Vice Director Eiichiro Osa and Mr. Sayedul Arefin, outlined the Master's training course to them, and exchanged opinions and ideas.

Then, the team went to the Bangladesh Water Development Board (DWDB), where Director General H. S. Mozaddad Faruque gave the team a warm welcome. ICHARM Director Takeuchi responded by thanking him for sending students to the Master's course. At the board, Chief Engineer Md Abu Taher Khandakar gave them a detailed presentation on the recent water-related disasters in Bangladesh. He was in charge of the Barisal region in southern Bangladesh.

After that, the team moved to the Center for Environmental and Geographic Information Service (CEGIS) to exchange opinions about research activities.



Photo 6-25 Researchers discuss research issues at BWDB.



Photo 6-26 Mr. H.S. Mozaddad Faruque
(Director of BWDB)



Photo 6-27 Mr. Md Abu Taher Khandakar
(Chief Engineer of BWDB)



Photo 6-28 Mr. Giasuddin Ahmed Choudhury
(Executive Director of CEGIS; left)

[February 8]

The field trip team went to Bogra, a river-side town in the middle reach of the Jamuna River with Mr. Khandakar of BWDB and Mr. Arefin of the JICA office to take a close look at river erosion and interview residents. Although there was a jetty for flood control, its tip was already washed out, and its foundation was considerably eroded. The Jamuna River can even shift its channel due to the power of a phenomenal amount of river discharge during flooding incomparable to Japanese rivers. To reduce even a little bit of the flow energy, the team members thought that large-scale structural measures are necessary. However, revetment works should be done quickly before major construction.



Photo 6-29 A jetty whose tip had been washed out



Photo 6-30 The jetty's foundation was considerably eroded.



Photo 6-31 Local residents walk along with IC staff.



Photo 6-32 Rice fields sprawling in the Bogra area

[February 9]

The team visited an area near Dhaka with Mr. Khandakar of BWDB and Mr. Arefin of the JICA office to observe flood control in place. One of the students in the Master's training course was from



Figure6-4 "Dhaka Integrated Flood Protection Project"

Bangladesh and studying the area for his research. They first went to the west side of Dhaka, where levees were already constructed.

Figure 6-4 is the outline of the Dhaka Integrated Flood Protection Project. Dhaka is topographically vulnerable to floods because rivers surround the city on its eastern, northern and western sides. Levees were built on the western side of the city, while they are still at the planning stage on the eastern side. In this research, the team looked at drain pump stations and the progress of the levee construction moving from north to south on the levees built on the western side.

BWDB personnel told the team that the levee construction was completed on the city's western side but people were suffering from severe water pollution. The city is expected to see a dramatic population increase in the future, and it is important to take necessary steps as soon as possible.



Photo 6-33 A view of downtown Dhaka from a pump station



Photo 6-34 Inside of a pump station



Photo 6-35,36,37 The three photos show the conditions around a port on the southern side of Dhaka. Protection walls and revetment works have already been implemented in this area.

6.4.3 India

[February 11]

The field trip team visited a town called Patna, located in the middle reach of the Ganga River with Mr. Surendre Kumar Singh. They observed the Bagmati River, a tributary of the Ganga River, running through Patna. They also had an opportunity to talk to Mr. Er. Walil Ahmad Khan, a chief engineer in the Bagmati Project. He outlined the progress of the levee construction in the area.



Photo 6-38 Levee under construction



Photo 6-39 Mr. Er. Wakil Ahmad Khan explains about the project to Director Takeuchi.

[February 12]

The team visited the JICA India Office and had a talk with Vice Director Asakuma. Then they went to the India Institute of Technology (IIT) to meet Professor A. K. Gosain, a director of the Computer Services Center. Director Takeuchi had a lecture on ICHARM outline to the students of IIT.

The team also met Mr. B. S. Ahuja, the chairperson of the Central Water Commission (CWC), and other commission members at their office. The commission actually plays an important role in selecting students for the Master's training course. The team explained about the training course and requested to continue sending students. In India, however, capable personnel in national public offices have usually a Master's degree, and it was difficult to find good candidates without a Master's degree.



Photo 6-40 Director Takeuchi talks with a JICA staff Ms. Asakuma.



Photo 6-41 the India Institute of Technology (IIT)



Photo 6-42 Director Takeuchi talks with Professor A. K. Gosain



Photo 6-43 Director Takeuchi makes a lecture.



Photo 6-44 Audience



Photo 6-45 Mr. B. S. Ahuja, CWC chair, shakes hands with Director Takeuchi.

6.5 Conclusion

There were two principal purposes for this field trip to the three Asian countries. One of them was to thank directors and other staff members in the affiliations of the students and JICA local offices for sending their personnel to the ICHARM Master's training course. ICHARM staff on the trip team also requested them to continue sending capable students to the Master's course from the next year on, explaining about academic skills, requirements and eligibility required of students to successfully complete the training course. The other main purpose was to conduct research on rivers and flood damage status in each country as well as flood control strategies and flood damage mitigation efforts. To do this, ICHARM staff was able to achieve better understanding of regions and basins which the students were studying in their research and further incorporate the research results in future training curriculum.

The trip was extremely effective despite its tight schedule. The team visited many affiliations of the Master's course students, built closer ties with them, explained about ICHARM, discussed issues, and requested to continue sending capable students to the training course. In addition, the team had great opportunities to take a close look at local situations of flood control, which can significantly contribute to future training activities.

Furthermore, the team also exchanged ideas and views on future ICHARM research and training with many organizations.

Chapter 7 : Overall Conclusion

7.1 Achievements in the Master's training course

ICHARM emphasizes “training” as one of the three important pillars along with “research” and “information networking.” ICHARM has conducted the JICA Flood Hazard Mapping training course for four consecutive years and contributed every year to the JICA River and Dam Engineering training course (reorganized for FY2008 as the Comprehensive River and Dam Management training course). Moreover, in 2007, the centre conducted the Comprehensive Tsunami Disaster Prevention training course funded by UN/ISDR.

This one-year Master's course on disaster management, which is problem solving-oriented, is an important addition to ICHARM's training activities. The planning and management of this course further strengthen the organization's capability in this area. The opportunity also allows ICHARM to contribute to solving water issues in the target countries of this course through the assistance for the students in writing their Master's theses. This is one of the successful practices by ICHARM, which is an embodiment of “Localism,” one of the keywords for ICHARM activities.

The Master's course has also made substantial contributions to “information networking,” another principal pillar of ICHARM. In December 2007, the Asia-Pacific Forum was held at Beppu in Oita Prefecture, Japan. The students were very helpful in getting necessary information on their native regions and helped ICHARM considerably that hosted a session in the forum. At another occasion, they also helped the centre quickly collect useful information on the cyclone damage in Bangladesh. They also play a vital role as a bridge between ICHARM and their affiliations, which has greatly improved the centre's view on local conditions and needs. This worldwide information networking through students will definitely help ICHARM with its future activities, and close contact should be kept with them even after their graduation from the course.

7.2 Messages from the graduates

Md. AMINUL Islam (Bangladesh) 	<i>I have already completed nearly one year in Japan. Only few days left to go back to my country. I learned about flood disasters, its mitigation techniques and essential policy required for sustainable management of flood disasters. I got improved knowledge on overall flood disaster management from professors, experts and course specific field observation. I hope this knowledge will be helpful in my country to improve our flood condition. I am returning with full of hopes to implement my proposed action plan. I would like to appreciate the policy of Government of Japan for transferring knowledge and technology of disaster mitigation to us. Best wishes to new comer friends.</i>
Muhammad MASOOD (Bangladesh) 	<i>It is a great opportunity for me to be a participant of one-year Masters Program on Flood-related Disaster Mitigation. I am also feeling proud as a participant of 1st batch of this course. Course curriculum is successfully completed, as GRIPS, PWRI, ICHARM and JICA are managing it well. I enjoyed the environment of my institute campus and also my time in Japan especially in Tsukuba with comfort. My acquired knowledge helped me to formulate an action plan of a project which I wish to implement after going back to my country. Bangladesh is a disaster prone country like Japan. So, as a participant from Bangladesh, I hope my acquired knowledge from Japan will be very much helpful for my country.</i>
Khanindra Barman (India) 	<i>It is a great opportunity for me to participate in the one year Master's degree program of Water-related Risk Management Course of Disaster Management. I passed one year in Japan very quickly. I have been to many important places of Japan. I could learn many things about Japan. I did my disaster management course in such a country that has a lot of experience of all types of natural disasters on this planet. We learned a lot of things about water-related disasters and their mitigation. The program of this course is very well organized. I am thankful to all the Professors, Researchers, team leader, coordinator for whom our course became a grand success. At last, I would like to wish grand success for the next course and best wishes to the new comer friends.</i>
Mitra Baral (Nepal) 	<i>Oh...it's already one year of time in Japan. Within few days we are returning to involve in the development activity of our own country with professional confidence. From Japan, we learned about flood disasters, its mitigation techniques and essential policy required for sustainable management of flood disasters. Lectures from professors, experts and course specific observation has broadened our mind on overall flood disaster management. Another important achievement for me from this course is that I could overview our weakness in disaster management. In order to solve the problems with community</i>

	approach of flood disaster management, I am returning with full of hopes to implement mine proposed action plan. I would like to appreciate the policy of Government of Japan for transferring knowledge and technology of disaster mitigation to us. Certainly, it's going to be an essential and primary tool for disaster mitigation in Nepal. At last, I would like to wish grand success of the course in coming days and best wishes to new comer friends.
DAI Minglong (China) 	After finishing one year of study on water-related disaster mitigation in ICHARM, I think ICHARM has supplied us a well-organized course. Many famous professors gave us different kinds of lectures, and we learned how Japan did in flood control, sabo works, dam construction and management. I'm sure this year is very useful for my future career. My action plan is "Further Study on Dam-break flood in Mid-down Stream of Han River". Applying 2-D or 3-D model and a more accurate geometric data, I will go on researching the dam-break effect fatherly. To my next year classmates, I want to say ICHARM is a good place for study. Here, facility is nice, ICHARM staffs are warm-hearted and always available when you need help. Wish you have a better study than us.
Ye, Lily (China) 	This one-year course gives me many ideas about the solutions of flood-related disaster mitigation based on Japan's experiences. Deeply I realize the weakness in China in comparison with our situation. As a member involving in the field of flood-related disaster mitigation, I feel more responsibilities we have to shoulder. My action plan is about flood hazard mapping in Mengwa Detention Basin. In China there are 157,800 people living inside 97 detention areas with a total area of 180.4km². Hopefully this project will lay a solid foundation for the management of detention areas in China. ICHARM provides a very good platform to share their successful experiences in flood-related disaster mitigation with developed countries, which is a forevermore beneficial move to enhance human's capability to mitigate flood-related disasters. Let's treasure the chance to update our knowledge about flood-related disaster mitigation and shoulder the great task with our passion.
Yasuo Kannami (Japan) 	Before taking part in this course, I do not know a lot how much effort Japan has made for living with natural disaster. This course gave me a kind of pride of Japan. After taking this course, I like Japan more. This course gave me a lot of new idea and experiences, which will be useful in my work and in my life. Japan is like a department store of prevention work against natural disasters. All participants may not be able to utilize it directly but I believe they must get a lot of idea that can apply to their country. And I also believe their action will make their country

	<i>safer against water-related disaster.</i> <i>I hope those who are in charge of natural disaster prevention work can join this course as much as possible and they bring back some idea from Japan.</i> <i>For Japanese, joining this course must be very special experience so that you can get not only knowledge about natural disaster but also international exchange. You may also find good things of Japan.</i>
Hirohisa MIURA (Japan) 	<i>I cannot believe that one year passed since this course started. In this sense, I was able to concentrate on study and individual study in this course. It was the first experience to spend time in an international atmosphere with students from the various countries. It was best time in my life.</i> <i>I learned that there are a lot of issues of flood disaster that must be solved all over the world. I want to challenge to solve some of such issues with knowledge and technology that I learned in this course.</i> <i>Finally, I would like to express my deepest gratitude to all people who encouraged and helped me during this course.</i>
Ryota Ojima (Japan) 	<i>I had a great opportunity to get a chance to study in Master's Program on Flood-related Disaster Mitigation.</i> <i>I obtain a lot of knowledge which is required in my work in the future and lecture.</i> <i>I also had a chance to visit Dhaka for my master thesis. I could see the real situation of the flood and talk with local residents. I learned the importance of visiting field and it was a remarkable experience for me.</i> <i>During my study, I was staying in JICA center in Tsukuba. I could make a lot of friends who have different way of thinking and culture. It was really good time that I can not experience in normal life in Japan.</i> <i>I am sure that this course can provide the not only the technical knowledge but also a chance to make a friend and human relationship.</i>

-Acknowledgements-

The program completed its first year from September 2007 to September 2008 without major troubles and problems. This is due to many others who gave us a lot of support both directly and indirectly. The organizers would like to express great thanks to lecturers from universities and public offices despite their busy schedules. The gratitude should also go to those in local public offices and the regional offices of the MLIT, as well as local residents. They were all willing to arrange their schedules around the students' field trips and spent time for informative talks with them.

Reference 1

General Information

INFORMATION ON GROUP TRAINING COURSE
TRAINING FOR EXPERT ON FLOOD-RELATED
DISASTER MITIGATION

“WATER-RELATED RISK MANAGEMENT” COURSE
A master's degree program
by GRIPS and ICHARM / PWRI
JFY 2007

集團：洪水関連災害専門家育成

COURSE NO.: J-07-00835

(Project No.: 0780043)

September 30, 2007 – September 19, 2008



THE GOVERNMENT OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY



I. Course Background and Overall Goal

In recent years, the number and scale of water-related disasters, flood in particular, have been increasing and resulted in massive losses of lives and livelihoods. These losses often offset years of hard-won social and economic development. Particularly in developing countries, losses are about five times higher per unit of gross domestic product (GDP) than those of rich countries. Managing flood risks has therefore become a priority for alleviating poverty, ensuring socioeconomic progress and securing the gains of development. The World Conference on Disaster Reduction (2005) identified the principal limitations and challenges to the implementation of sustainable framework for action in disaster risk reduction to include: 1) governance, organizational, legal and policy frameworks; 2) risk identification, assessment, monitoring and early warning; 3) knowledge management and education; 4) reduction of underlying risk factors; 5) preparedness for effective response and recovery.

It is clear that to tackle these challenges, developing countries are in emerging need to build the countries knowledge hub and know-how in integrated flood management. To this end, Japan International Cooperation Agency (JICA) and the International Centre for Water Hazard and Risk Management (ICHARM) have co-organized this training course on “Water-related Risk Management” to train water practitioners and disaster experts in the field of mitigation of water-related disasters in developing countries. Designed to achieve the highest international standard in disaster management and risk reduction in the trainees’ respective countries, this training course is fully accredited by the National Graduate Institute for Policy Studies (GRIPS) and it will lead after one year of intensive course works, research and on-site training to a Master’s Degree, “Master of Disaster Management” to be awarded by GRIPS and the Public Works Research Institute (PWRI).

The overall goal of this training course is to develop the trainee’s capacity to practically manage the problems and issues concerning water-related disasters in local levels and to contribute for socio-economic and environmental improvements in regional and national levels in developing countries. Students are expected to become an independent investigator in the areas of integrated flood disaster management, who is equipped with the most advance technical and legal know-how to enhance the basic understand of the challenges of flood risks and to translate this knowledge back to a practical water-related disaster reduction strategies including poverty reduction and the promotion of sustainable development at local, national and regional level.

About GRIPS (<http://www.grips.ac.jp/>)

The National Graduate Institute for Policy Studies (GRIPS) is a graduate school and research institute. GRIPS was established in October 1997. GRIPS aims to be an international center of excellence for the education of future leaders in the policy arena, for the advancement of policy research, and for the systematic collection and dissemination of policy-related information.

About ICHARM and PWRI (<http://www.icharm.pwri.go.jp/>, <http://www.pwri.go.jp/eindex.htm>)

ICHARM was established in March 2006 based on the agreement between the Japanese Government and UNESCO hosted by the Public Works Research Institute of Japan (PWRI). ICHARM mission is to be the Centre of Excellence to provide and assist implementation of the best practicable strategies to localities and nations for water-related disasters. PWRI is the renowned practice oriented research institute serving for more than 80 years since its establishment. It was governmental up to 2001 and now an Incorporated Administrative Agency.

About JICA training program (<http://www.jica.go.jp/>)

Japan International Cooperation Agency (JICA) has been offering training programs as one of the major means of supporting developing countries. PWRI has been contributing to the program since 1969.

Remarks:

*The curriculum of this course is approved as a master's degree program by *GRIPS and **PWRI. Achieving required credits during the training, the participants will be awarded a Master's degree, "Master of Disaster Management" by *GRIPS and **PWRI. Accordingly this training is very demanding. Applicants, with an excellent demonstrable educational and professional background, should be highly motivated and confident enough to pursue and attain the requirement of the program so that they can obtain the degree.*

**GRIPS -National Graduate Institute for Policy Studies
**PWRI -Public Works Research Institute*

II. Course Description

1. Course Title (No.):

Training for expert on flood-related disaster mitigation (J0700835)

2. Course Objective/Outcome:

The overall goal of this training course is to develop the trainee's capacity to practically manage the problems and issues concerning water-related disasters in local levels and to contribute for socio-economic and environmental improvements in regional and national levels in developing countries.

3. Course Outputs:

The participants will become:

- (1) Knowledgeable about the recent practices in integrated flood risk management in various localities in the world.
- (2) Able to define the requirements for local/national effective risk reduction including public policies and design a local/national risk management frameworks, institutional coordination and management mechanisms including all stakeholders.

- (3) Able to develop local/national indicators to detect and monitor changes in the basis of emergency responses and disaster risk reduction policies and to monitor the status and effectiveness of these policies.
- (4) Able to contribute for the implementation of plans developed based on the identified integrated risk management policy by making them underpinned by a clear financial, institutional and legislative framework.
- (5) Able to develop risk management strategies considering all the management cycle components, namely emergency response, recovery, mitigation and preparedness taking into account risk perception and communication issues and emerging threats such as global warming and climate change.

After the training course, participants are expected to:

- (1) Identify concerned issues and tasks in their home country by understanding of the historical, institutional and legislative backgrounds of flood disaster prevention in Japan, and finally draw up an action plan to overcome those issues and to undertake relevant tasks.
- (2) Realize the need of flood disaster reduction schemes in their home country.
Plan a flood disaster prevention/reduction project and finally draw up a workable action plan.
- (3) Understand and acquire the knowledge and techniques of flood risk assessment and risk reduction.
Create a flood hazard map.
- (4) Understand and acquire the knowledge and techniques of project planning for flood control (including dams and sediment control).
Figure out the tasks to be performed in the target river basin in their home country, and finally draw up a detail action plan, part of which is required to be tested for its validity during the training course.

4. Duration:

30 September 2007 – 19 September 2008

5. Total Number of Participants and Candidate Countries:

- (1) Number of Participants;
5 participants
- (2) Candidate Countries; (8 countries)
Afghanistan, Bangladesh, China, Ethiopia, India, Nepal, Philippines, Thailand

6. Eligible/Target Organization:

Organizations concerning river management or water-related disasters

- Target Group -

Technical officials, engineers or researchers in the field of water management

7. Language to be used in this Course:

English

8. Course Program:

1) Preparatory Phase

After receiving the "Notice of Acceptance", each participant has to make an "Inception Report". The Instruction will be delivered to the participants at the same time of "Notice of Acceptance".

2) Program in Japan

This training course consists of lectures, hands-on training sessions, field trips and an individual study.

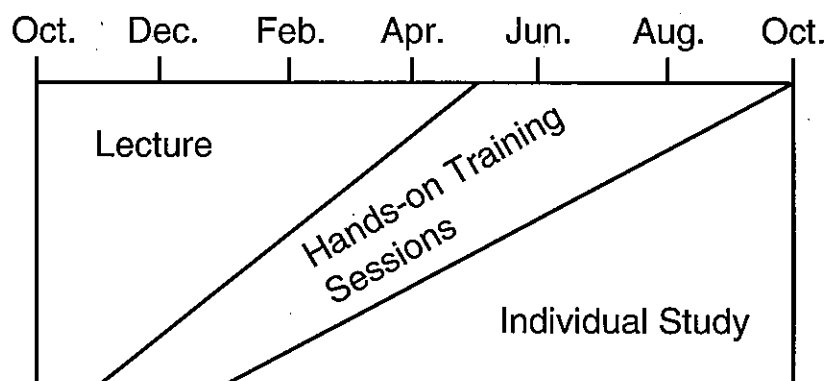


Fig. 1

This course is composed of various subjects as follows (Please see ANNEX III for the detailed information on the subjects):

Table 1 Contents of this course

Orientation	Opening Ceremony, Interview, Guidance PC setting Computer programming
Disaster Management Policy	Disaster Management Policy - <i>Social System against Disasters</i> - <i>Education on Basic Knowledge for Disasters</i> - <i>Policy for Infrastructure</i> - <i>Land-use and Regulation</i> - <i>Policy Making Process for Disaster</i>
	Disaster Risk Management - <i>International activities for disaster mitigation</i> - <i>Housing and urban policies in Japan</i> - <i>Community based disaster risk management</i> - <i>Practical risk assessment</i>
Basic Subjects Related to Flood Risk Management	Hydrological Observation, Modeling & Forecasts - <i>Hydrological observation</i> - <i>Frequency analysis</i> - <i>Run-off prediction modeling</i> - <i>Field study</i>
	Hydraulics - <i>Foundation of water flow theory</i> - <i>Application of water flow theory</i> - <i>Tour of laboratory</i>
Integrated Flood Risk Management	IFRM(1) Basic Concepts of IRBM, IFRM & Global Trends - <i>Outline</i> - <i>Water-related disasters around the world</i> - <i>Integrated basin-wide sediment management</i> - <i>International activities for disasters</i>

	- Flood control measures coping with global warming - Country report
	IFRM(2) Non-structural Measures & Community Defense - History of administrative aspect of disaster management - Flood control plan and measures around the world - Disaster management planning - Education and drill - Human action and social psychology - Community defense - Discussion
	IFRM(3) IRBM & Structural Measures - Flood control planning - Economic assessment of flood control plan - Field survey - Concept of integrated flood management and its application - Integrated river basin management
Hazard Mapping & Evacuation Planning	Hazard Mapping & Evacuation Planning - Flood risk assessment - Outline of flood hazard map - Topography of river and its alluvial plains - Inundation analysis - Hazard map of debris flow - Town watching - Discussion
Sustainable Reservoir Development & Management	Sustainable Reservoir Development & Management - Outline of dams - Flood control with dams - Water resources planning - Dam and environment - Dam and regional development - Dam construction - Role of dams in 21st century
Control Measures for landslide & Debris Flow	Control Measures for landslide & Debris Flow - Outline of control measures for landslide & debris flow - Theory of control measures for debris flow - Theory of control measures for landslide
Introduction to International Cooperation	Introduction to International Cooperation - Human security - Community development - Poverty reduction
Individual Study	

3) Developing Phase

After completing the training course at ICHARM, each participant is required to write and submit a follow-up report to JICA/ICHARM every three months in two years.

III. Conditions and Procedure for Application

1. Responsibility of the Participating Countries/Organizations:

- (1) It is strongly requested for the governments of the participating countries and organizations to nominate applicants who fulfill the qualifications for this training course and who have high motivation and strong commitments to address the current problems in their countries or organizations.
- (2) If any of the applicants the participating countries or organizations have nominated is accepted, they are required to provide full support for their own applicants to focus on writing an "Inception Report". The Instruction will be delivered to the participants at the same time of "Notice of Acceptance".

- (3) After successfully completing the training course at ICHARM, the organizations are expected to encourage their participants to share what they have learned in the course with the people and organizations concerned.

2. Qualifications of Applicants:

Applicants should:

- (1) be nominated by their governments in accordance with the procedures described in III 4
- (2) be university graduates in civil engineering, water resource management, or disaster mitigation
- (3) be engineers or technical officers who have three or more year of experience in the field of flood management
- (4) have working knowledge of civil engineering, especially of hydraulics and hydrology
- (5) be familiar with mathematics such as differentiation and integration techniques.
- (6) be able to write research reports on the individual study in English
- (7) have a good command of English --- minimum TOEFL score; 79 (Internet Based Test), 213 (Computer Based Test) or 550 (Paper Based Test), or equivalent
*Applicants with these scores normally can give and understand detailed directives or instruction with technical terms
**In this course, this level should be equivalent to "good" at the question, "13. LANGUAGE PROFICIENCY" in A2A3 Form
- (8) be over 22 and under 40 years of age
- (9) be in good health to undergo the course of training (Please be fully understand that the training over a long period like this course may pose risks to pregnancy)
- (10) not be military personnel

3. Required Documents:

The following documents must be submitted to the JICA Office (or the Embassy of Japan) in applicant's country by **June 29, 2007.**

Note: Applications without any of these 3 items will be out of the selections

- (1) **Nomination Form: One (1) original and three (3) copies**
- (2) **Application Materials for GRIPS*/PWRI** Master Program (See ANNEX I)**
All of the curriculum of this course is approved as a master's degree program by GRIPS and PWRI. Therefore, each applicant is required to prepare and submit all of the following materials for admission to GRIPS/PWRI Master Program as written in ANNEX I
 - ☐ Application Form
 - ☐ Certificate of Health
 - ☐ Certificate of Employment
 - ☐ Two letters of Recommendation
 - ☐ Official Transcripts or Official Copy of Transcripts
 - ☐ Official Copy of Diploma or Degree Certificate

□Official Document Certifying English Proficiency

(3) Application Report (See ANNEX II)

Each applicant must prepare an "Application Report" on the present situation of his/her organizations and problems related to his/her own job. It must be typewritten in English, no more than 4 pages (12-point font, double-spaced, A4 size paper) and in the required format (see ANNEX II). It must be submitted together with the Nomination Form (A2A3). The Application Report will be used only for screening purpose and as training materials, only if applicant is selected.

*GRIPS -National Graduate Institute for Policy Studies

**PWRI -Public Works Research Institute

4. Procedure for Application and Selection:

(1) Submission of the Documents for Selection:

Governments desiring to nominate applicants for this training course must submit (1) original nomination forms, (2) application materials for the GRIPS/PWRI Master Program, and (3) "Application Reports" to a JICA office (or the Embassy of Japan) by **June 29, 2007**.

(2) Selection:

- 1) A JICA office (or the Embassy of Japan) will accept the documents for selection, carry out the pre-screening, and send the documents to JICA TSUKUBA in charge of this training course.
- 2) JICA TSUKUBA will carry out the screening jointly with PWRI at the end of June, 2007 and decide the passed applicants out of those who fulfill the set qualifications described above in III.2.

Note: Applications without any of the required documents will be out of the selections.

- 3) The applicants who pass the documentation screening should seat for an oral examination that will be conducted by JICA and PWRI through the JICA-Net System at a JICA office around mid-July, after which qualified applicants will be decided.
- 4) A committee, which consists of GRIPS and PWRI, will screen the above qualified applicants academically with the Application materials such as Official Transcripts by the end of July (The schedule is undelayable).
- 5) The applicants who are accepted to participate to the Course will be decided by a faculty council of GRIPS finally.

** In case the number of applicants is more than the capacity of this course, some applicants may not be accepted due to the limited number of seats even though they fulfill the requirements.

(3) Notice of Acceptance:

A JICA office (or Embassy of Japan) will inform each applying government of acceptance or non-acceptance of its nominees' application **no later than August 25, 2007**.

In case of acceptance, Acceptance Agreement from GRIPS will be sent together.

5. Rules for Attendance:

Participants are required to observe the following rules for attending the training course:

- (1) Not to bring any of their family members.
- (2) Return to their home countries at the end of the training course according to the international travel schedule designated by JICA.
- (3) Refrain from being engaged in political activities or any form of employment for profit or gain while residing in Japan.
- (4) Properly follow the rules and regulations of their places of accommodation and not to change accommodations that initially designated by JICA.
- (5) Obey the rules while attending the lectures or sessions at the training course.

Note: Participants disobeying these rules will be subject to disciplinary action.

6. Certificate, Diploma and Master's Degree

- (1) Participants who have successfully completed the training course will be awarded a certificate by JICA.
- (2) Participants who have successfully achieved the required credits will be awarded a Master's Degree, 'Master of Disaster Management' by GRIPS and PWRI.

V. Administrative Arrangements

1. Travel to Japan:

(1) Air Ticket:

A round-trip air ticket between an international airport designated by JICA and Japan will be borne by JICA.

(2) Travel Insurance:

Travel insurance is not insured by JICA.

2. Accommodation:

JICA will arrange the following accommodation for the participants while in Japan:

Tsukuba International Center (JICA TSUKUBA)

Address: 3-6 Koyadai, Tsukuba, Ibaraki, 305-0035, Japan

TEL: +81-29-838-1117, FAX: +81-29-838-1790 (81: country code for Japan, 3: area code)

*If no room is available at JICA TSUKUBA, JICA will arrange alternative accommodations for the attendees.

3. Living Expenses:

Following expenses will be provided for the attendees by JICA:

- (1) Allowances for accommodation, living expenses, outfits and shipping
- (2) Expenses for study tours; basically paid in the form of train ticket(s) or chartered bus.

- (3) Free medical care for the attendees who become ill after arrival in Japan
(Cost related to pre-existing illness, pregnancy or dental treatment is not included)
- (4) Expenses for program implementation including materials

For more details, please see p. 9-16 of the brochure for the attendees, titled "KENSU-IN GUIDE BOOK", which will be given to the selected attendees before (or at the time of) the pre-departure orientation.

4. Course Implementing Organization:

International Centre for Water Hazard and Risk Management under the auspices of UNESCO (ICHARM) at Public Works Research Institute (PWRI)

Address: 1-6 Minamihara, Tsukuba, Ibaraki-ken, 305-8516 Japan

TEL: +81-29-879-6809, FAX: +81-29-879-6709

E-mail: icharm@pwri.go.jp, URL: <http://www.icharm.pwri.go.jp>

5. Training Course and Master's Degree Program

The curriculum of this training course is approved as a master's degree program by GRIPS and PWRI.

National Graduate Institute for Policy Studies (GRIPS)

Address: 7-22-1 Roppongi, Minato-ku, Tokyo, 106-8677 Japan

TEL: +81-3-6439-6046, FAX: +81-3-6439-6050

E-mail: admissions@grips.ac.jp, URL: <http://www.grips.ac.jp>

*The entrance examination fee, admission fee and tuition for the Master's Degree Program will be provided by PWRI.

6. Pre-Departure Orientation:

A pre-departure orientation for the participants will be held at a JICA office (or Embassy of Japan) in participant's country to give insights on travel to Japan, living conditions, programme features etc. Participants will watch a video entitled "Training in Japan," and receive a textbook and cassette tape titled "Simple Conversation in Japanese." A brochure and the KENSU-IN GUIDE BOOK will be also provided to each participant if they have not received it in advance.

ANNEX:

ANNEX I	Application Materials for GRIPS/PWRI Master Program
ANNEX II	Instruction for Application Report
ANNEX III	Syllabus of the Training Program

Reference

Founded in 1974, the Japan International Cooperation Agency (JICA) is an implementation agency for technical assistance, focusing on systems building, organization strengthening and human resource development that will enable developing countries to pursue their own sustainable socio-economic development.

The training program for overseas participants is one of JICA's main cooperation programs. Under this program, JICA invites professionals in various fields including administrative officials, engineers and technicians from developing countries to Japan and provide them with skills and technology needed in their countries as well as the chance to share knowledge and experience with participants from other countries. Through this program, participants are expected to acquire skills and technology or create knowledge, bring them back to their countries, and apply them in their workplaces or societies with necessary modifications according to their own conditions to achieve their specific objectives.

JICA's Mission

We, as a bridge between the people of Japan and developing countries, will advance international cooperation through the sharing of knowledge and experience and will work to build a more peaceful and prosperous world.

Oath of Service

With passion and pride, as professionals in development cooperation, we will perform our work responsibly and energetically with love and a sense of duty; we will encourage and support the participation of the Japanese people in our work; we will work as partners to those in need of assistance; and we will strive to fill the world with hope and happiness by promoting peace and sustainable development.

CORRESPONDENCE

For enquires and further information, please contact the JICA office, or the Embassy of Japan. Address any other correspondence to:

Tsukuba International Center
Japan International Cooperation Agency
(JICA TSUKUBA)

Address: 3-6 Koyadai, Tsukuba, Ibaraki, 305-0035, Japan

TEL: +81-29-838-1117, FAX: +81-29-838-1790

E-mail: tbictp1@jica.go.jp

ANNEX I

Application Materials for GRIPS/PWRI Master Program

Instructions: Please read this information carefully before completing application materials for the GRIPS/PWRI program.

Any false or misleading statement or incomplete or inaccurate application may be the basis for denial of screening for admission or, if admitted, dismissal from the School. All questions must be answered, and the application form must be signed and dated. You must notify the School of any changes of status in any part of your application that may occur after the date of the signature on the application form and write an explanation required thereby within 30 days of the status change. **All materials submitted by an applicant become the property of GRIPS and will not be returned.**

Documents to be submitted: Applicants are requested to submit the following documents (**preferably in one complete set so as to avoid delays in further evaluation**):

Step1: Prepare the following supporting documents:

Please check ☒ whether you have submitted all the necessary documents

- ☐ completed application form
- ☐ certificate of health
- ☐ 2 identical photographs (30 x 40 mm) (please paste one photograph on the application form)
- ☐ 2 letters of recommendation in sealed envelopes
- ☐ official certificate of employment describing applicant's present job title and employer. Information on civil servant qualification (e.g. BCS, IAS, IRS, CSS) should be also included there, if applicable. (The certificate of employment must bear official seal and sign obtained from the employer)
- ☐ official transcripts or official copies of transcripts from all undergraduate and postgraduate institutions previously attended*
- ☐ official copy of diploma or degree certificate from all undergraduate and graduate institutions previously attended*
- ☐ TOEFL/IELTS score report, or other official document certifying English proficiency of those applicants whose undergraduate education was in a language other than English (GRIPS TOEFL code no. 9040, a photocopy of your TOEFL/IELTS score report acceptable). Native speakers of English are exempted from this requirement. Those who received (under) graduate education in English should submit an official document confirming that the language of instruction was English.

Notes

1. Letters of recommendation must be submitted in sealed envelopes, signed across the seal. Recommendations should be written by people who have supervised the applicant either in an academic or work capacity. Preferably, one letter should be written by a university professor and the other should be written by a senior member of the applicant's present work place.
2. An official copy means a certified true copy of the original document with an official seal obtained from the administration office of the university attended. A true copy of the original document certified by a notary public may also be accepted. Copies attested by organizations/persons not having notary/legal functions will not be accepted or considered for screening.
3. All documents must be presented in English. Translations in English without an official seal obtained from the administration office of the university attended or without a signature of the recommender or the drawer of the document are not acceptable.

4. Faxed documents and digital copies sent through e-mail are not acceptable.

INQUIRIES

Details regarding to the graduate program may be obtained at the following websites:

<http://www.grips.ac.jp>

Disaster Management Policy Program by GRIPS and PWRI In Co-operation with JICA, Japan

Photographs

Please write your
name on the back of
each photo
Size: 30 x 40 mm

APPLICATION FORM

(Type or write in block letters)

PERSONAL DATA

1. Full Name

_____ as written in your passport.

_____ Name to be used in correspondence, if different from above.

2. Date and Country of Birth _____ 3. Age (as of April 1st 2007) _____
MM/DD/YY country

4. Gender: ☐ male ☐ female5. Marital Status: ☐ single ☐ married

6. Citizenship _____
(as written in your passport)

7. Present Employer

_____ Does your organization belong to a central or regional authority? ☐ central ☐ regional

8. Present Position

9. Work Address

tel: _____ fax _____ email _____
country code city code local number country code city code local number

10. Home Address

tel: _____ fax _____ email _____
country code city code local number country code city code local number

11. Present Mailing Address: ☐ home ☐ work ☐ other, namely:

tel: _____ fax _____ email _____
country code city code local number country code city code local number

APPLICATION INFORMATION

12. List names and locations of educational institutions attended, with dates of attendance and degrees attained or expected. Please attach academic transcripts from all colleges and universities listed.

Elementary Education – Secondary Education (before higher education)	Dates (from–to)	Period of Schooling
		years months

Higher Education	Institution and Location	Dates (from–to) Month Year	Period of Schooling	Degree	Major
Undergraduate level			years months		
Graduate level			years months		
Total years of schooling (including elementary and secondary education)			years months		

13. [Optional] Undergraduate GPA _____ out of maximum GPA scale of (e.g. 4.0) _____, if available

Please see appendix for GPA calculation procedure

14. [Optional] Graduate GPA _____ out of maximum GPA scale of _____, if available
15. [Optional] Undergraduate Class obtained or Passed Division _____, if available
16. [Optional] Graduate Class obtained or Passed Division _____, if available
17. Honors and Awards received:

18. TOEFL/IELTS scores or any other qualifications to show English proficiency:

☐ TOEFL: _____ ☐ IELTS: _____

score date score date

☐ Undergraduate/graduate education instructed in English (please submit certificate)

All applicants must submit either TOEFL/IELTS score report (photocopy is acceptable) or an official document with the attestation from the university confirming that undergraduate/graduate education was instructed in English.

19. List below two persons familiar with your past academic or professional activity whom you have requested letters of recommendation.

1. _____

name position and affiliation

2. _____

name position and affiliation

20. List all previous employment, starting with your current employment (please make sure to submit an official certificate of employment from the present employer)

[illegible]

21. Summarize your present duties and responsibilities. Applicants with specific civil servant qualification and ranking (e.g. BCS, IAS, IRS, CSS) are also requested to provide the respective information. Please use only this space and pay special attention to completing this section, as it is often the principal source of information for evaluating the relevance of the program to the applicants' assignment, as well as the relative merits of each applicant.

[illegible]

22. Are there any other factors that you would like to have the admissions committee consider in evaluating your application (e.g., personal background, leadership role)?

CERTIFICATION

I certify that to the best of my knowledge all information given above is correct and complete, and I understand that any omission or misinformation may invalidate my admission or result in dismissal.

Signature of applicant

date

You need to submit this completed application form together with the supporting documents listed on page 1. Please use the check list to make sure that you have collected all the supporting documents.

Disaster Management Policy Program by GRIPS and PWRI In Co-operation with JICA, Japan

CERTIFICATE OF EMPLOYMENT

EMPLOYER DETAILS

Name of Organization: _____

Address of Organization: _____

tel: _____ fax _____ email _____
country code city code local number country code city code local number

EMPLOYEE DETAILS

This is to certify that _____
full name of the applicant

has been employed by this organization from _____ to _____
MM/DD/YY MM/DD/YY

Present position, rank, responsibilities, etc.: _____

LEAVE OF ABSENCE APPROVAL SECTION

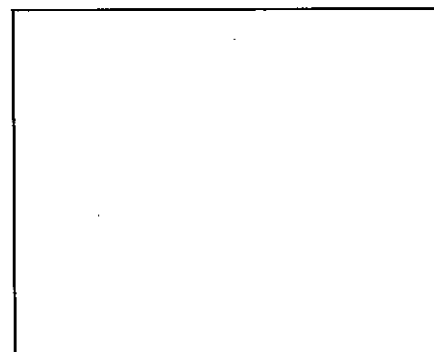
I will approve one year of Leave of Absence for the above employee to participate in the Disaster Management Policy program, if he/she is admitted to GRIPS and PWRI.

Name of person completing the form _____

Position/Title: _____

Signature

Date



*Please put Official Stamp or Seal on this space.

Disaster Management Policy Program by GRIPS and PWRI In Co-operation with JICA, Japan

LETTER OF RECOMMENDATION

TO THE APPLICANT: Complete this section. Give this form to the person whom you have asked to recommend you.

Applicant's Name _____
as written in your passport

Recommender's Name _____

TO THE RECOMMENDER: Please enclose the completed recommendation in a sealed envelope and sign it across the seal. Return the signed, sealed envelope to the applicant. If you prefer, you may write a separate letter and attach it to this form. This recommendation letter will remain confidential and will be used for the applications screening procedure only.

1. How long have you known the applicant? _____ years _____ months
2. In what capacity have you known the applicant?

3. How often have you seen him/her?
☐ daily ☐ weekly ☐ monthly ☐ rarely
4. In comparison with other students/staff in the same field whom you have known, how would you rate the applicant's overall academic or administrative ability?
☐ Truly Exceptional (one of the best you have known)
☐ Outstanding (highest 5%)
☐ Excellent (next highest 5%)
☐ Good (strong ability, but not in top 10%)
☐ Average (upper 50%)
☐ Below Average (lower 50%, but recommended)
☐ Not Recommended
5. Please evaluate as *excellent*, *average* or *poor*:

	<i>excellent</i>	<i>average</i>	<i>poor</i>
Academic Performance	☐	☐	☐
Intellectual Potential	☐	☐	☐
Creativity & Originality	☐	☐	☐
Motivation for Graduate Study	☐	☐	☐
6. (For university professors and instructors only)
Is the academic record indicative of the applicant's intellectual ability? If no, please explain.

7. Discuss the applicant's competence in his/her field of study, as well as the applicant's career possibilities as a professional worker, researcher or educator. In describing such attributes as motivation, intellect, and maturity, please discuss both strong and weak points. Specific examples are more useful than generalizations.

8. Discuss the applicant's character and personality. Please comment on his/her social skills, emotional stability, leadership skills and reliability.

9. Additional comments, if any.

10. How would you evaluate the applicant's overall suitability as a candidate for admission to the Graduate Program of GRIPS and PWRI?

☐ outstanding

☐ good

☐ average

☐ poor

Name of person completing this form _____

Position/title _____

Organization _____

Address _____

phone _____ fax _____ email _____

Signature

date

Disaster Management Policy Program by GRIPS and PWRI In Co-operation with JICA, Japan

LETTER OF RECOMMENDATION

TO THE APPLICANT: Complete this section. Give this form to the person whom you have asked to recommend you.

Applicant's Name _____
as written in your passport

Recommender's Name _____

TO THE RECOMMENDER: Please enclose the completed recommendation in a sealed envelope and sign it across the seal. Return the signed, sealed envelope to the applicant. If you prefer, you may write a separate letter and attach it to this form. This recommendation letter will remain confidential and will be used for the applications screening procedure only.

1. How long have you known the applicant? _____ years _____ months
2. In what capacity have you known the applicant?

3. How often have you seen him/her?
☐ daily ☐ weekly ☐ monthly ☐ rarely
4. In comparison with other students/staff in the same field whom you have known, how would you rate the applicant's overall academic or administrative ability?
☐ Truly Exceptional (one of the best you have known)
☐ Outstanding (highest 5%)
☐ Excellent (next highest 5%)
☐ Good (strong ability, but not in top 10%)
☐ Average (upper 50%)
☐ Below Average (lower 50%, but recommended)
☐ Not Recommended
5. Please evaluate as *excellent*, *average* or *poor*.

	<i>excellent</i>	<i>average</i>	<i>poor</i>
Academic Performance	☐	☐	☐
Intellectual Potential	☐	☐	☐
Creativity & Originality	☐	☐	☐
Motivation for Graduate Study	☐	☐	☐
6. (For university professors and instructors only)
Is the academic record indicative of the applicant's intellectual ability? If no, please explain.

7. Discuss the applicant's competence in his/her field of study, as well as the applicant's career possibilities as a professional worker, researcher or educator. In describing such attributes as motivation, intellect, and maturity, please discuss both strong and weak points. Specific examples are more useful than generalizations.

8. Discuss the applicant's character and personality. Please comment on his/her social skills, emotional stability, leadership skills and reliability.

9. Additional comments, if any.

10. How would you evaluate the applicant's overall suitability as a candidate for admission to the Graduate Program of GRIPS and PWRI ?

☐ outstanding ☐ good ☐ average ☐ poor

Name of person completing this form _____

Position/title _____

Organization _____

Address _____

phone _____ fax _____ email _____

Signature

date

Disaster Management Policy Program by GRIPS and PWRI In Co-operation with JICA, Japan

CERTIFICATE OF HEALTH (to be completed by the examining physician)

Please fill out (PRINT/TYPE) in English. Do not leave any items blank.

☐ Male Date of Birth : _____
☐ Female Age : _____

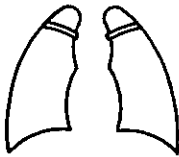
Name : _____
 Family name, First name Middle name

1. Physical Examinations

- (1) Height _____ cm, Weight _____ kg
 (2) Blood pressure _____ mm/Hg ~ _____ mm/Hg, Blood Type [A B O], [RH +, -]
 Pulse Rate _____ /min, ☐ regular ☐ irregular
 (3) Eyesight : (R) _____ (L) _____
 without glasses with glasses or contact lenses
 (4) Hearing : ☐ normal ☐ impaired speech : ☐ normal ☐ impaired

2. Please describe the results of physical and X-ray examinations of applicant's chest X-ray (X-ray taken more than 6 months prior to the certification is NOT valid).

Lung : ☐ normal ☐ impaired Date _____ Film No. _____



Describe the condition of applicant's lung.

Cardiomegaly : ☐ normal ☐ impaired
 If impaired: Electrocardiograph, ☐ normal ☐ impaired

3. Disease Treated at Present

☐ Yes (Disease: _____) ☐ No

4. Past history : Please indicate with + or - and fill in the date of recovery

Tuberculosis....☐ (. .), Malaria....☐ (. .), Other communicable disease....☐ (. .)
 Epilepsy....☐ (. .), Kidney Disease....☐ (. .), Heart Diseases....☐ (. .)
 Diabetes....☐ (. .), Drug Allergy....☐ (. .), Psychosis....☐ (. .),
 Functional Disorder in extremities....☐ (. .)

5. Laboratory tests

Urinalysis : glucose (), protein (), occult blood ()
 Feces : Parasite (egg of parasite) (+, -)
 ESR : _____ mm/Hr, WBC count : _____ x10³/μl, RBC : _____ x10⁶/μl,
 Hemoglobin: _____ g/dl, AST (GOT): _____ u/l, ALT (GPT): _____ u/l,

6. Please describe your impression.

7. In view of the applicant's history and the above findings, is it your observation his/her health status is adequate to pursue studies in Japan ?

yes ☐ no ☐

Date: _____ Signature: _____

Physician's Name in Print: _____

Office/Institution: _____

Address: _____

Appendix**How to calculate your GPA**

If GPA is not indicated on your transcript, take the value of the grade earned and multiply by the number of credits earned for each course. Add "total value" and divide by the "total number of credits" earned to get GPA.

Example:

Value of Letter Grades

A	4.0
A-	3.7
B+	3.3
B	3.0
B-	2.7
C+	2.3
C	2.0
C-	1.7
D+	1.3
D	1.0
D-	0.7
F	0.0

grade	value		# of credits		total value
A	4.0	x	3	=	12.00
B-	2.7	x	4	=	10.80
A-	3.7	x	3	=	11.10
C+	2.3	x	3	=	6.90
total			13	/	40.80
GPA				=	3.14

Application Report
for the Group training course on
"Training for Experts on Flood-related Disaster Mitigation"

Note:

- (1) This Report must be submitted with the Nomination Form (A2A3).
- (2) This report must be prepared by the applicant himself/herself.
- (3) Applicants without this report will be out of the selection.

Remark:

- (1) If there are any applicants who want electronic copy of this report, please contact JICA Tsukuba (tbictp1@jica.go.jp).
- (2) If available, please send us directly this Application Report to JICA Tsukuba (tbictp1@jica.go.jp) by E-mail.

1. Please fill your following information.

- (1) Name:
- (2) Organization:
- (3) Present Post:
- (4) Country:
- (5) E-mail:

2. Please fill the following subjects about your organization and department.

What are the Missions/Objectives/Roles of your organization? And what are the activities of your organization to achieve those goals?

** Please add the item according to the situation of your organization.*

- (1) Mission, Objective, Role:

Activities:

- (2) Mission, Objective, Role:

Activities:

3. Please show your Organization Chart and indicate your position.

Please attach your organization chart.

4. Please explain your job experience related to flood control and water resources.** Please add the item according to your situation.*

(1) Period:

- 1) Organization;
- 2) Position;
- 3) Outline of duties;

(2) Period:

- 1) Organization;
- 2) Position;
- 3) Outline of duties;

5. Do you have any issues which you have to solve or any difficulties on your work?☐ Yes ☐ No

If "yes", please describe the issues, difficulties and reasons (technical and organizational/institutional) in detail.

** Please add the item according to your situation.***5.1 Technical Aspects**

(1) Issues, Difficulties:

Reason:

(2) Issues, Difficulties:

Reason

5.2 Organizational/Institutional Aspects

(1) Issues, Difficulties:

Reason:

(2) Issues, Difficulties:

Reason:

6. In the fields of Flood-related disaster mitigation, what topics are you interested in?

Please describe the topics and the reason why you are interested in those topics

** Please add the item according to your situation.*

(1) Topics, Subjects:

Reason:

(2) Topics, Subjects:

Reason:

7. Please explain your expectation from this training course.

8. Please explain your future plans to apply expected results of the training program in order to tackle flood-related mitigation projects after returning to your country.

9. If you have any request, please write down.

ANNEX III

Syllabus of the Training Program

Category	Title	Subtitle	Contents
Orientation	Orientation	Opening Ceremony	
		Orientation, Interview, Guidance	The facilities including PCs and laboratories of flood control facilities are introduced.
		Computer	Practice on FORTRAN programming for scientific computing
Disaster Management Policy	Disaster Management Policy		Disaster mitigation policy and risk management of national level are discussed with practical system and laws.
	Disaster Risk Management		A broad understanding of disaster risk management, including prevention/preparedness before disasters and recovery/reconstruction after disasters is provided.
Basic Subjects Related to Flood Risk Management	Hydrological Observation, Modeling & Forecasts	Hydrological observation	Observation of precipitation and discharge, Satellite observation, Drawing H-Q curve
		Frequency analysis	Probability paper, Extreme distribution, Fitness, trend
		Run-off prediction modeling	Theory of run-off prediction, Modeling of rainfall run-off, Flood forecasting using flood prediction model
		Field trip	Field trip to observation site
	Hydraulics	Foundation of water flow theory	Fundamental equations for flow, Over flow and jump flow, Gradually-varied flow and unsteady flow
		Application of water flow theory	Multi-crossed channel, Junction flow and diversion flow, Retarding basin, Overflow equation, Secondary flow, bent and alternative bar
		Tour of laboratory	Tour of laboratory
Integrated Flood Risk Management (IFRM)	IFRM(1) Basic Concepts of IRBM*, IFRM & Global Trends	Outline	Aim of the course, Water management, Principles of disaster occurrence
		Water-related disasters around the world	Relationship between national power and water-related disasters, Recent water-related disasters around the CRED EM-DAT Data, Water-related disasters in Monsoon Asia and Japan
		Integrated basin-wide sediment management	Problems and measures of sediment management in Japan
		International activities for disasters	History of disaster prevention, Activities by UNESCO, WMO and other international organizations
		Flood control measures coping with global warming	Present situation of global warming and flood control measures coping with it
		Country report	Presentation and discussion of country report
	IFRM(2) Non-structural Measures & Community Defense	History of administrative aspect of disaster	Japanese administrative system, history and Present situation and history of disaster prevention around the world
		Flood control plan and measures around the world	Flood control planning and measures around the world
		Disaster management planning	Disaster management plan in communities, Preparedness, warning, evacuation and restoration
		Education and drill	Field survey, Participation in flood fighting drills
		Human action and social psychology	Mentality and action of flood victims
		Community defense	Culture and education for disaster management, Awareness for flood disasters
		Discussion	Discussion of action plan

	IFRM(3) IRBM & Structural Measures	Flood control planning	Flood control plan in Japan, How to draw flood control plan
		Economic assessment of flood control plan	B/C analysis for flood control measures
		Field survey	Fundamental river management policy and structural measures for flood control in the A and B class rivers in Japan
		Concept of integrated flood management and its application	Theory, effects and examples of integrated flood management, Discussion
		Integrated river basin management	Basin-oriented flood risk management in 21st century
Hazard Mapping & Evacuation Planning	Hazard Mapping & Evacuation Planning	Flood risk assessment	Risk assessment, Vulnerability assessment
		Outline of flood hazard map	Role of flood hazard map in integrated flood risk management, Flood hazard map in the world
		Topography of river and its alluvial plains	Topography of alluvial plains, Classification of topographical map in view of flooding
		Inundation analysis	Past inundated area, Modeling and forecasting inundation area, Mapping by Geographical Information System
		Hazard map of debris	Outline of hazard map of debris flow
		Town watching	Field survey and interview, Proposal for improving smooth evacuation
		Discussion	Presentation and discussion by participants
Sustainable Reservoir Development & Management	Sustainable Reservoir Development & Management	Outline of dams	History of dams around the world, What dams brought in Japanese development
		Flood control with dams	Prediction of inflow and discharge planning, Flood control operation of dams
		Water resources planning	Outline of water resources, Prospect of water resources in 21 st century
		Dam and environment	Assessment of natural environment around dams, Assessment of social environment related to dams
		Dam and regional development	Power development, Economic assessment, Field survey and interview
		Dam construction	Concrete dams, Embankment dams, Multipurpose dams, Cost allocation
		Role of dams in 21st century	Introduction of discussion in ICOLD
Control Measures for landslide & Debris Flow	Control Measures for landslide & Debris Flow	Outline of control measures for landslide & debris flow	Background of control measures for landslide & debris flow, Vulnerability and factors of disasters, Culture for disaster management
		Theory of control measures for debris flow	Planning control measures, Assessment of social ability, Hydraulics of flash flood
		Theory of control measures for landslide	Outline of landslide, Dynamics of landslide, Warning, evacuation and emergent response
Introduction to International Cooperation	Introduction to International Cooperation	Human security	Concepts of HS, HS and Japanese ODA
		Community	Participatory Development
		Poverty Reduction	Poverty Reduction, Japanese ODA, JICA's Assistance

Hands-on training	Hydrological Observation, Modeling & Forecasts	Hydrological observation	Observation of precipitation and discharge, Satellite observation, Drawing H-Q curve
		Frequency analysis	Probability paper, Extreme distribution, Fitness, trend
		Run-off prediction modeling	Modeling of rainfall run-off, Flood forecasting using flood prediction model
	Hydraulics	Foundation of water flow theory	Fundamental equations for flow, Over flow and jump flow, Gradually-varied flow and unsteady flow
		Application of water flow theory	Multi-crossed channel, Junction flow and diversion flow, Retarding basin , Overflow equation, Secondary flow, bent and alternative bar
	Integrated Flood Risk Management	Flood control planning	Flood control plan, Drawing flood control plan
		Economic assessment of flood control plan	B/C analysis for flood control measures
	Hazard Mapping & Evacuation Planning	Geographical Information System	Usage of GIS
		Inundation analysis	Modeling and forecasting inundation area, Mapping by Geographical Information System
		Evacuation planning	Proposal for improving smooth evacuation
	Sustainable Reservoir Development & Management	Flood control with dams	Prediction of inflow and discharge planning, Flood control operation of dams
		Design of dam	Concrete dams, Embankment dams, Multipurpose dams, Cost allocation
	Control Measures for landslide & Debris Flow	Control measures for debris flow	Planning control measures, Hydraulics of flash flood
		Control measures for landslide	Dynamics of landslide, Countermeasures of landslide
Individual Study			From January to the end of the training period are assigned for individual study, in which each participant makes a research on a specific subject and write a paper under the direction of an instructor. The subject and the instructor for individual study are decided through discussion with the ICHARM teaching staff.

Reference 2

Recruitment Information

2007-2008
GRIPS and PWRI/ICHARM
Disaster Management Policy Program
Water-related Risk Management Course

as of May 2007

INFORMATION FOR APPLICANTS

ADMISSION OF FOREIGN STUDENTS

The overall goal of this master's program is to develop the student's capacity to practically manage the problems and issues concerning water-related disasters in local levels and to contribute for socio-economic and environmental improvements in regional and national levels in developing countries. Students are expected to become an independent investigator in the areas of integrated flood disaster management, who is equipped with the most advance technical and legal know-how to enhance the basic understand of the challenges of flood risks and to translate this knowledge back to a practical water-related disaster reduction strategies including poverty reduction and the promotion of sustainable development at local, national and regional level.

The academic year runs from October through September. Students must spend a minimum of one year at GRIPS, which is sufficient for those students who study intensively to satisfy all the requirements for a master's degree.

To be eligible for admission to this master's program, an applicant

- 1) must hold a bachelor's degree or its equivalent from a recognized/accredited university of the highest standard in the field of civil engineering, water resource management, or disaster mitigation.
- 2) must have working knowledge of civil engineering, especially of hydraulics and hydrology.
- 3) must be familiar with mathematics such as differentiation and integration techniques.
- 4) must satisfy the English language requirements with a minimum TOEFL score of 550 (Computer-Based Test (CBT) 213, Internet-Based Test (iBT) 79), IELTS 6.0 or its equivalent.
- 5) must be in good health.

The application deadline is June 29. Applicants are evaluated for admission based on their academic record and intellectual distinction, personal characteristics, motivation, evidence of leadership, promise for management and career growth, and work experience. Applicants may be asked to go through interviews. The final result of screening for admission will be announced by the end of July at the latest.

APPLICATION PROCEDURES

Instructions: Please read this information carefully before completing the application materials.

Any false or misleading statement or incomplete or inaccurate application may be the basis for denial of screening for admission or, if admitted, dismissal from GRIPS. All questions must be answered, and the application form must be signed and dated. You must notify GRIPS of any changes of status in any part of your application that may occur after the date of the signature on the application form. A written explanation must be submitted to GRIPS within 30 days of the status change. **All materials submitted by an applicant become the property of GRIPS and will not be returned.**

Documents to be submitted: Applicants are requested to submit the following documents (**preferably in one complete set so as to avoid delays in further evaluation**):

Please check whether you have prepared all the necessary documents.

- ☐ Completed application form
- ☐ Certificate of health
- ☐ 1 photograph (30 x 40 mm) Please paste it on the application form.
- ☐ 2 letters of recommendation in sealed envelopes
- ☐ Official certificate of employment describing applicant's present job title and employer details. Information on civil servant qualification (e.g. BCS, IAS, IRS, CSS) should be also included there, if applicable. (The certificate of employment must bear official seal and sign obtained from the employer)
- ☐ Official transcripts or official copies of transcripts from all undergraduate and postgraduate institutions previously attended
- ☐ Official copy of diploma or degree certificate from all undergraduate and graduate institutions previously attended
- ☐ TOEFL/IELTS score report, or other official document certifying English proficiency of those applicants whose undergraduate education was in a language other than English (GRIPS TOEFL code no. 9040, a photocopy of your TOEFL/IELTS score report acceptable). Native speakers of English are exempted from this requirement. Those who received (under) graduate education in English should submit an official document confirming that the language of instruction was English.
- ☐ Application Fee (JPY 30,000)
- ☐ Financial Statement
- ☐ Copy of Foreign Resident Registration Card *only if you are a foreign resident in Japan.

Notes

1. Letters of recommendation must be submitted in sealed envelopes, signed across the seal. Recommendations should be written by people who have supervised the applicant either in an academic or work capacity. Preferably, one letter should be written by a university professor and the other should be written by a senior member of the applicant's present work place.
2. An official copy means a certified true copy of the original document with an official seal obtained from the administration office of the university attended. A true copy of the original document certified by a notary public may also be accepted. Copies attested by organizations/persons not having notary/legal functions will not be accepted or considered for screening.
3. Application Fee should be paid to the following account by June 29. If you fail to do so, your application can not be considered. Please pay transfer charge at your expense. Check is not acceptable.

Name of the bank:	Sumitomo Mitsui Banking Corporation
Name of the branch:	Tokyo Koumubu, Japan
Account No.:	151884
Name of the account:	The National Graduate Institute for Policy Studies

4. You are required to submit one of the following documents to indicate sufficient assets to cover the schooling and living expenses in Japan. We estimate Total Study Cost (School Expenses + Minimum Living Expenses) for the initial year at JPY 2,700,000 or USD 22,600 *approximate exchange rates: USD1=JPY 119.43 (as of April 27, 2007).

- 1) Official proof of available funding in a form of bank statement or an original letter from a bank showing liquid funds in Japanese yen or US dollars and dated within the past two months.
- 2) An original award letter from a scholarship provider (agency, company) showing total sum in US dollars or Japanese yen as well as general terms and conditions of the agreement.
- 3) Verification from a different sponsor (such as relative) with proof of ability to provide you with support in the form of an original bank statement or an original letter from a bank showing liquid funds in Japanese yen or US dollars and dated within the past two months.
5. All documents must be presented in English. Translations in English without an official seal obtained from the administration office of the university attended or without a signature of the recommender or the drawer of the document are not acceptable.
6. Faxed documents and digital copies sent through e-mail are not acceptable.

Where to submit your application:

Submit application to: Admissions Office
National Graduate Institute for Policy Studies (GRIPS)
7-22-1 Roppongi, Minato-ku
Tokyo 106-8677
Japan
Deadline: June 29, 2007

INQUIRIES

Inquiries should be made to: Admissions Office
National Graduate Institute for Policy Studies (GRIPS)
7-22-1 Roppongi, Minato-ku
Tokyo 106-8677, Japan

Phone: +81-3-6439-6046
Fax: +81-3-6439-6050
E-mail: admissions@grips.ac.jp
Website: <http://www.grips.ac.jp>

Disaster Management Policy Program by GRIPS and PWRI/ICHARM

APPLICATION FORM

(Type or write in block letters)

Photographs

Please write your
name on the back of
each photo
Size: 30 x 40 mm

PERSONAL DATA

1. Full Name

_____ as written in your passport.

_____ Name to be used in correspondence, if different from above.

2. Date and Country of Birth _____ 3. Age (as of October 1st 2007)

MM/DD/YY

country

4. Gender: ☐ male ☐ female

5. Marital Status: ☐ single ☐ married

6. Citizenship _____
(as written in your passport)

7. Present Employer

_____ regional

Does your organization belong to a central or regional authority?

☐ central ☐

8. Present Position

9. Work Address _____

tel: _____ - _____ - _____ fax: _____ - _____ - _____ email: _____
country code city code local number country code city code local number

10. Home Address _____

tel: _____ - _____ - _____ fax: _____ - _____ - _____ email: _____
country code city code local number country code city code local number

11. Present Mailing Address: ☐ home ☐ work ☐ other, namely:

tel: _____ - _____ - _____ fax: _____ - _____ - _____ email: _____
country code city code local number country code city code local number

APPLICATION INFORMATION

12. List names and locations of educational institutions attended, with dates of attendance and degrees attained or expected. Please attach academic transcripts from all colleges and universities listed.

Elementary Education – Secondary Education (before higher education)	Dates (from–to)	Period of Schooling
		years months

Higher Education	Institution and Location	Dates (from-to) Month Year	Period of Schooling	Degree	Major
Undergraduate level			years months		
Graduate level			years months		
Total years of schooling (including elementary and secondary education)			years months		

13. **[Optional]** Undergraduate GPA _____ out of maximum GPA scale of (e.g. 4.0) _____, if available

Please see appendix for GPA calculation procedure

14. **[Optional]** Graduate GPA _____ out of maximum GPA scale of _____, if available

15. **[Optional]** Undergraduate Class obtained or Passed Division _____, if available

16. **[Optional]** Graduate Class obtained or Passed Division _____, if available

17. Honors and Awards received:

18. TOEFL/IELTS scores or any other qualifications to show English proficiency:

☐ TOEFL: _____ ☐ IELTS: _____
score date score

date

☐ Undergraduate/graduate education instructed in English (please submit certificate)

All applicants must submit either TOEFL/IELTS score report (photocopy is acceptable) or an official document with the attestation from the university confirming that undergraduate/graduate education was instructed in English.

19. List below two persons familiar with your past academic or professional activity whom you have requested letters of recommendation.

1.	name	position and affiliation
----	------	--------------------------

2.	name	position and affiliation
----	------	--------------------------

CERTIFICATION

I certify that to the best of my knowledge all information given above is correct and complete, and I understand that any omission or misinformation may invalidate my admission or result in dismissal.

Signature of applicant

date

You need to submit this completed application form together with the supporting documents listed on page 2. Please use the check list to make sure that you have collected all the supporting documents.

Disaster Management Policy Program by GRIPS and PWRI/ICHARM

CERTIFICATE OF EMPLOYMENT

EMPLOYER DETAILS

Name of Organization: _____

Address of Organization: _____

tel: _____ - _____ - _____ fax : _____ - _____ - _____ email: _____
country code city code local number country code city code local number

EMPLOYEE DETAILS

This is to certify that _____
full name of the applicant

has been employed by this organization from _____ to _____
MM/DD/YY MM/DD/YY

Present position, rank, responsibilities, etc.: _____

LEAVE OF ABSENCE APPROVAL SECTION

I will approve one year of Leave of Absence for the above employee to participate in the Disaster Management Policy program, if he/she is admitted to GRIPS and PWRI/ICHARM.

Name of person completing the form _____

Position/Title: _____

Signature

Date



*Please put Official Stamp or Seal on this

space.

Disaster Management Policy Program by GRIPS and PWRI/ICHARM

LETTER OF RECOMMENDATION

TO THE APPLICANT: Complete this section. Give this form to the person whom you have asked to recommend you.

Applicant's Name _____
as written in your passport

Recommender's Name _____

TO THE RECOMMENDER: Please enclose the completed recommendation in a sealed envelope and sign it across the seal. Return the signed, sealed envelope to the applicant. If you prefer, you may write a separate letter and attach it to this form. This recommendation letter will remain confidential and will be used for the applications screening procedure only.

1. How long have you known the applicant? _____ years _____ months

2. In what capacity have you known the applicant?

3. How often have you seen him/her?

☐ daily ☐ weekly ☐ monthly ☐ rarely

4. In comparison with other students/staff in the same field whom you have known, how would you rate the applicant's overall academic or administrative ability?

- ☐ Truly Exceptional (one of the best you have known)
☐ Outstanding (highest 5%)
☐ Excellent (next highest 5%)
☐ Good (strong ability, but not in top 10%)
☐ Average (upper 50%)
☐ Below Average (lower 50%, but recommended)
☐ Not Recommended

5. Please evaluate as *excellent*, *average* or *poor*:

	<i>excellent</i>	<i>average</i>	<i>poor</i>
Academic Performance	☐	☐	☐
Intellectual Potential	☐	☐	☐
Creativity & Originality	☐	☐	☐
Motivation for Graduate Study	☐	☐	☐

6. (For university professors and instructors only)

Is the academic record indicative of the applicant's intellectual ability? If no, please explain.

7. Discuss the applicant's competence in his/her field of study, as well as the applicant's career possibilities as a professional worker, researcher or educator. In describing such attributes as motivation, intellect, and maturity, please discuss both strong and weak points. Specific examples are more useful than generalizations.

8. Discuss the applicant's character and personality. Please comment on his/her social skills, emotional stability, leadership skills and reliability.

9. Additional comments, if any.

10. How would you evaluate the applicant's overall suitability as a candidate for admission to the Graduate Program of GRIPS and PWRI/ICHARM?

☐ outstanding ☐ good ☐ average ☐ poor

Name of person completing this form _____

Position/title _____

Organization _____

Address _____

phone _____ fax _____ email _____

Signature

date

Disaster Management Policy Program by GRIPS and PWRI/ICHARM

LETTER OF RECOMMENDATION

TO THE APPLICANT: Complete this section. Give this form to the person whom you have asked to recommend you.

Applicant's Name _____
as written in your passport

Recommender's Name _____

TO THE RECOMMENDER: Please enclose the completed recommendation in a sealed envelope and sign it across the seal. Return the signed, sealed envelope to the applicant. If you prefer, you may write a separate letter and attach it to this form. This recommendation letter will remain confidential and will be used for the applications screening procedure only.

1. How long have you known the applicant? _____ years _____ months

2. In what capacity have you known the applicant?

3. How often have you seen him/her?

☐ daily ☐ weekly ☐ monthly ☐ rarely

4. In comparison with other students/staff in the same field whom you have known, how would you rate the applicant's overall academic or administrative ability?

- ☐ Truly Exceptional (one of the best you have known)
☐ Outstanding (highest 5%)
☐ Excellent (next highest 5%)
☐ Good (strong ability, but not in top 10%)
☐ Average (upper 50%)
☐ Below Average (lower 50%, but recommended)
☐ Not Recommended

5. Please evaluate as *excellent*, *average* or *poor*:

	<i>excellent</i>	<i>average</i>	<i>poor</i>
Academic Performance	☐	☐	☐
Intellectual Potential	☐	☐	☐
Creativity & Originality	☐	☐	☐
Motivation for Graduate Study	☐	☐	☐

6. (For university professors and instructors only)

Is the academic record indicative of the applicant's intellectual ability? If no, please explain.

7. Discuss the applicant's competence in his/her field of study, as well as the applicant's career possibilities as a professional worker, researcher or educator. In describing such attributes as motivation, intellect, and maturity, please discuss both strong and weak points. Specific examples are more useful than generalizations.

8. Discuss the applicant's character and personality. Please comment on his/her social skills, emotional stability, leadership skills and reliability.

9. Additional comments, if any.

10. How would you evaluate the applicant's overall suitability as a candidate for admission to the Graduate Program of GRIPS and PWRI/ICHARM?

☐ outstanding ☐ good ☐ average ☐ poor

Name of person completing this form _____

Position/title _____

Organization _____

Address _____

phone _____ fax _____ email _____

Signature

date

Disaster Management Policy Program by GRIPS and PWRI/ICHARM

CERTIFICATE OF HEALTH (to be completed by the examining physician)

Please fill out (PRINT/TYPE) in English. Do not leave any items blank.

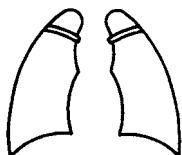
Name : _____, _____ ☐ Male Date of Birth : _____
Family name, First name Middle name ☐ Female Age : _____.

1. Physical Examinations

- (1) Height _____ cm, Weight _____ kg
 (2) Blood pressure _____ mm/Hg ~ _____ mm/Hg, Blood Type [A B O], [RH +, -]
 Pulse Rate _____ /min, ☐ regular ☐ irregular
 (3) Eyesight : (R) _____ (L) _____
 without glasses with glasses or contact lenses
 (4) Hearing : ☐ normal ☐ impaired speech : ☐ normal ☐ impaired

2. Please describe the results of physical and X-ray examinations of applicant's chest X-ray (X-ray taken more than 6 months prior to the certification is NOT valid).

Lung : ☐ normal ☐ impaired Date _____, Film No. _____.



Describe the condition of applicant's lung.

Cardiomegaly : ☐ normal ☐ impaired
 If impaired: Electrocardiograph, ☐ normal ☐ impaired

3. Disease Treated at Present

☐ Yes (Disease: _____) ☐ No

4. Past history : Please indicate with + or - and fill in the date of recovery

Tuberculosis.... ☐ (. .), Malaria.... ☐ (. .), Other communicable disease.... ☐ (. .)
 Epilepsy.... ☐ (. .), Kidney Disease... ☐ (. .), Heart Diseases... ☐ (. .)
 Diabetes.... ☐ (. .), Drug Allergy.... ☐ (. .), Psychosis.... ☐ (. .),
 Functional Disorder in extremities.... ☐ (. .)

5. Laboratory tests

Urinalysis : glucose (), protein (), occult blood ()
 Feces : Parasite (egg of parasite) (+, -)
 ESR : _____ mm/Hr, WBC count : _____ x10³/μl, RBC : _____ x10⁶/μl,
 Hemoglobin: _____ g/dl, AST (GOT): _____ u/l, ALT (GPT): _____ u/l,

6. Please describe your impression.

7. In view of the applicant's history and the above findings, is it your observation his/her health status is adequate to pursue studies in Japan ?

yes ☐ no ☐

Date: _____ Signature: _____

Physician's Name in Print: _____

Office/Institution: _____

Address: _____

Appendix

How to calculate your GPA

If GPA is not indicated on your transcript, take the value of the grade earned and multiply by the number of credits earned for each course. Add "total value" and divide by the "total number of credits" earned to get GPA.

Value of Letter Grades

A	4.0
A-	3.7
B+	3.3
B	3.0
B-	2.7
C+	2.3
C	2.0
C-	1.7
D+	1.3
D	1.0
D-	0.7
F	0.0

Example:

grade	value		# of credits		total value
A	4.0	x	3	=	12.00
B-	2.7	x	4	=	10.80
A-	3.7	x	3	=	11.10
C+	2.3	x	3	=	6.90
total			13	/	40.80
GPA				=	3.14

Reference 3

List of Students

List of Students
Water-related Risk Management Course of Disaster Management Policy Program

No.	Student Number of GRIPS	Country	Name	Present work/Office
1	MEE07175	China	Mr. DAI, Ming-Long 	Hydrology Engineer Division of Hydrology and Water Resources, Bureau of Hydrology, ChangJiang Water Resources Commission
2	MEE07176	Philippines	Mr. Jose Roy Harder LAGON 	Engineer II 6th Regional Office, Dept of Public Works and Highways
3	MEE07177	India	Mr. Khanindra BARMAN 	Assiatant Engineer Sivasagar Water Resource Division, Water Resource Dept., Govt. of Assam
4	MEE07178	Bangladesh	Mr. Md. Aminul ISLAM 	Assiatant Engineer Design Circle-2, Bangladesh Water Development Board
5	MEE07179	Nepal	Mr. Mitra BARAL 	Engineer Water Induced Disaster Prevention Division Office No.3, Water Induced Disaster Prevention Dept., Parwanipur, Bara
6	MEE07180	Bangladesh	Mr. Muhammad MASOOD 	Assiatant Engineer Design-1, Bangladesh Water Development Board
7	MEE07181	China	Ms. YE, Li-Li 	Hydrological operation and flood reporting service Bureau of Hydrology, Ministry of Water Resources
8	MEE07182	Japan	Mr. Yasuo Kannami (神波 泰夫) 	Engineer Pacific Consultants Co.,Ltd.
9	MEE07183	Japan	Mr. Hirohisa Miura (三浦 博久) 	Engineer Japan Water Agency
10	MEE07184	Japan	Mr. Ryota Ojima (尾島 亮太) 	Engineer CTI Engineering Co.,Ltd.
11	MEE07185	China	Mr. Ji Zhou 	Assistant Engineer River Department, Wu Xi Water Conservancy Bureau

Reference 4

Graduation Requirement Chart

Graduation Requirement Chart
講義名・演習名・単位数・責任教官一覧表

Category	Title	Instructor	Credit
I Required	Individual Study		10
II Recommend	Disaster Management Policy	Prof. Shigeru Morichi (GRIPS)	2
	Disaster Risk Management	Prof. Kenji Okazaki (GRIPS)	2
	Hydrological Observation, Modeling & Forecasting	Prof. JayawardenaAmithirigala (ICHARM)	2
	Hydraulics	Prof. Tadaharu Ishikawa (Tokyo Institute of Technology)	2
	Introduction to International Cooperation	Prof. Mikio Ishiwatari (JICA)	2
	Integrated Flood Risk Management (IFRM) (1) Basic Concept of IRBM, IFRM & Global Trend	Prof. Kuniyoshi Takeuchi (ICHARM)	2
	Integrated Flood Risk Management (IFRM) (2) Non-structural Measures & Community Defense	Prof. Kuniyoshi Takeuchi (ICHARM)	2
	Integrated Flood Risk Management (IFRM) (3) IRBM & Structural Measures	Prof. Shouji Fukuoka (Chuo Univ.)	2
	Flood Hazard Mapping & Evacuation Planning	Prof. Shigenobu Tanaka (ICHARM)	2
	Sustainable Reservoir Development & Management	Prof. Norihisa Matsumoto (Japan Dam Engineering Center)	2
	Control Measures for Landslide & Debris Flow	Prof. Shun Okubo (Japan Sabo Association)	2
III Elective	Practice on Hydrological Observation, Modeling & Forecasting	Prof. JayawardenaAmithirigala (ICHARM)	1
	Practice on Hydraulics	Prof. Tadaharu Ishikawa (Tokyo Institute of Technology)	2
	Practice on Integrated Flood Risk Management	Prof. Kuniyoshi Takeuchi (ICHARM)	1
	Practice on Hazard Mapping & Evacuation Planning	Prof. Shigenobu Tanaka (ICHARM)	1
	Practice on Sustainable Reservoir Development & Management	Prof. Norihisa Matsumoto (Japan Dam Engineering Center)	1
	Practice on Control Measures for Landslide & Debris Flow	Prof. Shun Okubo (Japan Sabo Association)	1

Reference 5

Course Syllabus

Subject Hydrological Observation, Modeling & Forecasting

Course number : DMP281E

Instructor : Prof. Amithirigala Widhanelage JAYAWARDENA

Term / Time : Fall through Winter

1 Course Description

This course provides the hydrological basis for water-related risk management. It includes hydrological observation, flood frequency analyses, precipitation-runoff modeling and flood forecasting. Observational technology includes, in addition to the conventional gauging technologies, the latest retrieval algorithm of precipitation from satellite measurements. Frequency analyses will be preceded by basic data processing and quality assurance methodology. Hydrological modeling covers several typical models for estimating evapo-transpiration, infiltration and flow generation. Flood forecasting includes inundation calculation.

2 Course Outline (Course Topics)

Week

1. Processes in the hydrological cycle and their observations
2. Remote sensing of precipitation; satellite observation
3. Measurement of runoff; rating curve
4. Statistical analysis of rainfall data; intensity-duration-frequency curves
5. Stochastic analysis of rainfall data; time series analysis; rainfall prediction (1)
6. Stochastic analysis of rainfall data; time series analysis; rainfall prediction (2)
7. Peak flow estimation; rational method
8. Hydrograph prediction; unit hydrograph methods
9. Rainfall-runoff modeling; lumped approach (1)
10. Rainfall-runoff modeling; stochastic approach (2)
11. Rainfall-runoff modeling; distributed approach (3)
12. Rainfall-runoff modeling; data driven approach (4)
13. Flood forecasting; Kalman filtering
14. Future trends
15. Examination

3 Grading

There are two components to grading.

- 1) Home work 40%
- 2) Final Examination 60%

Students are required to get 60% for each component.

4 Textbooks

Subject Hydraulics

Course number : DMP282E

Instructor : Prof. Tadaharu Ishikawa

Term / Time : Fall through Winter

1 Course Description

This course provides the hydraulic engineering basis for the water-related risk management. It covers the fundamental concepts of open channel hydraulics including the equation for one-dimensional flow, roughness of channel and normal depth, critical depth, subcritical flow, supercritical flow, over flow and jump flow, gradually varied flow, unsteady flow, multi-crossed channel. Students are expected to become able to calculate the flood wave propagation in a real river.

2 Course Outline (Course Topics)

Week

- 1 : Framework of fundamental equation
- 2 : Equation for 1-dimension flow
- 3 : Roughness of channel and normal depth
- 4 : Critical depth, Subcritical flow, Supercritical flow
- 5 : Quiz
- 6 : Tour of laboratory
- 7 : Over flow and jump flow
- 8 : Gradually varied flow (1)
- 9 : Gradually varied flow (2)
- 10 : Unsteady flow
- 11 : Multi-crossed channel
- 12 : Junction flow and diversion flow
- 13 : Retarding basin
- 14 : Curved area and bar
- 15 : Examination

3 Grading

Class participation (30%), Reports (30%), Final Examination(40%)

If a report is late for the deadline, it will be not evaluated.

4 Textbooks

4-1 Required

4-2 Others

Subject Introduction to International Cooperation

Course number : DMP283E

Instructor : Mr. Mikio Ishiwatari

Term / Time : Fall through Winter

1 Course Description

This course provides the basic knowledge on international cooperation: players, objectives, target people and implementation mechanism. Japan International Cooperation Agency (JICA) experiences on disaster mitigation and regional development, especially on working together with local community will be the central focus of the lecture. It also covers the subjects of human security in disaster mitigation, relation between gender and community based disaster mitigation. This lecture will orient the students how to write their master thesis which is requested to take a form of an implementation plan to be submitted to the donor agencies.

2 Course Outline (Course Topics)

Week

- 1 : ODA & JICA
- 2 : To minimize disasters –Lessons from Japan
- 3 : International cooperation in disaster mitigation (1)
- 4 : International cooperation in disaster mitigation (2)
- 5 : Human security in disaster mitigation
- 6 : International contribution of JDR: Japan Disaster Relief Team (1)
- 7 : International contribution of JDR: Japan Disaster Relief Team (2)
- 8 : Relationship between gender & disaster
- 9 : Outline of regional development with residents (1)
- 10 : Outline of regional development with residents (2)
- 11 : Outline of regional development with residents (3)
- 12 : Planning with the residents
- 13 : Community based disaster mitigation (1)
- 14 : Community based disaster mitigation (2)
- 15 : Examination

3 Grading

Active participation(30%), Reports(40%), Final Examination(30%)

4 Textbooks

4-1 Required

4-2 Others

Subject Practice on Hydrological Observation, Modeling & Forecasting

Course number : DMP284E

Instructor : Prof. Amithirigala Widhanelage JAYAWARDENA

Term / Time : Fall through Winter

1 Course Description

This course aims at consolidating the material covered in Course No. DMP281E “Hydrological Observation, Modeling & Forecasting”.

Exercises related to each topic will be given to the students and they will be discussed and explained. It also includes field survey.

Students performance at these exercises will be counted toward their grades.

2 Course Outline (Course Topics)

Week

- 1 : Rating curve
- 2 : Intensity-duration-frequency curves
- 3 : Probability distribution; fitting goodness of fit
- 4 : Stochastic modeling - Time series analysis and prediction (1)
- 5 : Stochastic modeling - Time series analysis and prediction (2)
- 6 : Peak flow estimation
- 7 : Derivation of unit hydrograph and Synthetic unit hydrographs
- 8 : Hands on practice on typical rainfall-runoff models (1)
- 9 : Hands on practice on typical rainfall-runoff models (2)
- 10 : Hands on practice on typical rainfall-runoff models (3)
- 11 : Hands on practice on typical rainfall-runoff models (4)
- 12 : Flood forecasting using Kalman Filter
- 13 : Quiz
- 14 : Field Trip (1)
- 15 : Field Trip (2)

3 Grading

There are two components to grading.

- 1) Home work 30%
- 2) Quiz 40%
- 3) Final Exam 30%

Students are required to get 60% for each component.

4 Textbooks

4-1 Required

4-2 Others

Subject Practice on Hydraulics

Course number : DMP285E

Instructor : Prof. Tadaharu Ishikawa

Term / Time : Fall through Spring

1 Course Description

This course aims at consolidating the material covered in Course No. DMP282E “Hydraulics”.

Exercises related to each topic will be given to the students and they will be discussed and explained. It also includes field survey.

Students performance at these exercises will be counted toward their grades.

2 Course Outline (Course Topics)

Week

- 1 , 2 : Framework of fundamental equation
- 3 , 4 : Equation for 1-dimension flow
- 5 , 6 : Roughness of channel and normal depth
- 7 , 8 : Critical depth, Subcritical flow, Supercritical flow (1)
- 9 , 10 : Critical depth, Subcritical flow, Supercritical flow (2)
- 11 , 12 : Over flow and jump flow (1)
- 13 , 14 : Over flow and jump flow (2)
- 15 , 16 : Gradually varied flow (1)
- 17 , 18 : Gradually varied flow (2)
- 19 , 20 : Gradually varied flow (3)
- 21 , 22 : Unsteady flow (1)
- 23 , 24 : Unsteady flow (2)
- 25 , 26 : Multi-crossed channel (1)
- 27 , 28 : Multi-crossed channel (2)
- 29 , 30 : Junction flow and diversion flow

3 Grading

Class participation (40%), Reports (60%)

If a report is late for the deadline, it will be not evaluated.

4 Textbooks

4-1 Required

4-2 Others

Subject IFRM(1) Basic Concepts of IRBM, IFRM & Global Trends

Course number : DMP380E

Instructor : Dr. Kuniyoshi Takeuchi

Term / Time : Fall

1 Course Description

This course provides the basic concepts of “Integrated Flood Risk Management (IFRM)” including disaster risk, natural hazard, societal vulnerability, coping capacity etc. as the basis of this Master Program of “Water-related Risk Management”. It also provides the current global and international trend and activities including Japanese flood management experiences, Hyogo Framework for Action, climate change, sustainable development etc. Those will be lectured by various international opinion leaders invited by ICHARM.

2 Course Outline (Course Topics)

Week

- 1 : Outline of integrated flood risk management (1)
- 2 : Outline of integrated flood risk management (2)
- 3 : Global trends of water-related disasters
- 4 : Basic concepts of IFRM
- 5 : Flood plain management
- 6 : Lessons from the past flood
- 7 : Japanese experiences
- 8 : Global trends (1)
- 9 : Global trends (2)
- 10 : International activities
- 11 : Effects of climate change (1)
- 12 : Effects of climate change (2)
- 13 : Project assessment (1)
- 14 : Project assessment (2)
- 15 : Examination

3 Grading

Active participation(30%), Reports(40%), Final Examination(30%)

4 Textbooks

4-1 Required

4-2 Others

Subject IFRM(2) Non-structural Measures & Community Defense

Course number : DMP381E

Instructor : Dr. Kuniyoshi Takeuchi

Term / Time : Fall through Winter

1 Course Description

This course focuses on the non-structural measures for Integrated Flood Risk Management (IFRM). They include institutional framework, flood insurance, education, flood preparedness, early warning, community defense, human behavior and social psychology. In community defense, the importance of human networking and organization underpinned by historically developed disaster culture will be emphasized. Students are expected to provide some local experiences from their home countries followed by some group discussions.

2 Course Outline (Course Topics)

Week

- 1 : Outline of Non-structural measures & Community defense
- 2 : Institutional framework
- 3 : Flood preparedness (1)
- 4 : Flood preparedness (2)
- 5 : Education
- 6 : Emergency response
- 7 : Recovery & Rehabilitation
- 8 : Human behavior and social psychology
- 9 : Early warning (1)
- 10 : Early warning (2)
- 11 : Community defense (1)
- 12 : Community defense (2)
- 13 : Flood insurance
- 14 : Forestation
- 15 : Examination

3 Grading

Active participation(30%), Reports(40%), Final Examination(30%)

4 Textbooks

4-1 Required

4-2 Others

Subject IFRM(3) IRBM & Structural Measures

Course number : DMP382E

Instructor : Prof. Shoji FUKUOKA

Term / Time : Fall through Winter

1 Course Description

This course provides the basic knowledge necessary for selecting and designing the structural measures for IFRM. The course first describes the river administration and planning for application of IFRM. Especially the methodology of comprehensive river management will be emphasized that includes planning of flood control, flood hydraulics and sediment movement to river channels and dam reservoirs. This will be followed by specific technologies of channel control and channel improvement.

2 Course Outline (Course Topics)

Week

- 1 . Outline, planning and administration of rivers
- 2 . River Design (1) Procedure of river planning, Plan/longitudinal /cross section of rivers
- 3 . River Design (2) Designed discharge, High water level, Observation of floods
- 4 . River Design (3) Meaning of observation of discharge and water height, Design and planning of dikes
- 5 . River Design (4) Design of medium and small size rivers
- 6 . River Channel Planning (1) Hydraulic of flood flow, Water surface profile, Marks of flood level
- 7 . River Channel Planning (2) Hydraulic structures – dike, revetment, Spur dike, weir
- 8 . River Channel Planning (3) Dam, Reservoir, Diversion/Confluence
- 9 . River Channel Planning (4) Sediment transport, Scour, Sedimentation, Transportation, Measurement and estimation of sediment load
- 1 0 . River Channel Planning (5) Form of river bed, Sand wave , Bar, Meandering
- 1 1 . River Management (1) Maintenance and management of river
- 1 2 . River Management (2) River management under construction
- 1 3 . Integrated River Basin Management (1)
- 1 4 . Integrated River Basin Management (2)
- 1 5 . Examination

3 Grading

Reports (20%) Final examination (80%)

4 Textbooks

4-1 Required

4-2 Others

prints made by the instructors

Subject Hazard Mapping & Evacuation Planning

Course number : DMP383E

Instructor : Mr. Shigenobu Tanaka

Term / Time : Fall

1 Course Description

This course provides not only general knowledge on flood hazard maps (FHM) in Japan and the world, but also professional knowledge and techniques which are indispensable for FHM such as run-off analysis, GIS and inundation analysis. In addition, students will also learn/understand information to be included in FHM, how to disseminate and utilize FHM through town watching (field survey and interviewing).

2 Course Outline (Course Topics)

Week

- 1 : Outline of flood hazard map
- 2 : Evacuation Planning
- 3 : Inundation analysis (1)
- 4 : Inundation analysis (2)
- 5 : Mapping and GIS
- 6 : Anticipated inundation area in Flood Hazard Map
- 7 : Latest technology for FHM
- 8 : Application of AROS data for FHM
- 9 : Topography of river and its alluvial plains
- 10 : Dissemination and Utilization of FHM
- 11 : Town Watching (1)
- 12 : Town Watching (2)
- 13 : Flood Hazard Map around the World
- 14 : Discussion
- 15 : Examination

3 Grading

Active participation (40%), Reports (30%), Final Exam (30%)

If a report is late for the deadline, it will be not evaluated.

4 Textbooks

4-1 Required

4-2 Others

Subject Sustainable Reservoir Development & Management

Course number : DMP384E

Instructor : Dr. Norihisa Matsumoto

Term / Time : Fall through Winter

1 Course Description

This course provides the basic ideas of dam reservoir design and construction. The lecture starts from the multiple objectives of dam reservoirs and looks into their environmental (including sediments) and societal impacts. The lecture covers the basic methodologies of planning of capacity and site selection, environmental impact assessment, sediment management and operation and maintenance of dam reservoirs. The students are expected to experience a preliminary but concrete process of environmental assessment of reservoirs and gets insight of the role of reservoirs dealing with climate changes.

2 Course Outline (Course Topics)

Week

- 1 . Outline of Dam Engineering
- 2 . Flood Control Plan
- 3 . Flood Control Operation
- 4 . Water Resources Planning
- 5 . Planning of Multi-purpose Dam
- 6 . Benefits of Dams
- 7 . Environmental Impact of Dams (1)
- 8 . Environmental Impact of Dams (2)
- 9 . Sediment Management in Reservoirs (1)
- 1 0 . Sediment Management in Reservoirs (2)
- 1 1 . Dam Construction (1)
- 1 2 . Dam Construction (2)
- 1 3 . Dam Management
- 1 4 . Effective Use of Existing Dams
- 1 5 . Roles of Dams in 21st Century

3 Grading

Class participation (30%) 、 Report and Final examination (70%)

If you miss the deadline for reports, your reports will only be evaluated for a certain percentage of what they are supposed to be:

Up to seven days: 70%

Eight days or longer: 50%

4 Textbooks

4-1 Required

4-2 Others

Subject Control Measures for Landslide & Debris Flow

Course number : DMP385E

Instructor : Dr. Shun Okubo

Term / Time : Fall through Winter

1 Course Description

This course provides the necessary knowledge and understanding of landslide and debris flow phenomena and their control measures necessary to exercise the IFRM. The lecture will illustrate the devastating phenomena and the causes of landslides and debris flows and provide the basic concepts of sabo works which control both hill slopes and channels. It will cover the important role of hazard mapping for sediment-related disasters in both structural and non-structural measures. The students are guided to some sabo protection sites near by Tsukuba area.

2 Course Outline (Course Topics)

Week

- 1 . Outline of sediment-related disasters
- 2 . Introduction to sabo projects
- 3 . Countermeasures for sediment-related disasters
- 4 . Hazard mapping for sediment-related disasters
- 5 . Comprehensive sediment-related disaster measures
- 6 . Countermeasures for earthquake-induced natural dams
- 7 . Sabo works in arid area and reforestation of degraded lands
- 8 . Volcanic sabo works
- 9 . Application of sabo works and landslide countermeasures to overseas countries
- 1 0 . Introduction of landslides
- 1 1 . Characteristics and topography of landslides
- 1 2 . Stability analysis for landslide
- 1 3 . Survey and emergency response for landslide
- 1 4 . Maintenance measures for roads and reservoirs in landslide areas
- 1 5 . Permanent measures for landslide damage reduction

3 Grading

Class participation (30%) A Report and Final examination (70%)

4 Textbooks

4-1 Required

4-2 Others

Subject Practice on Integrated Flood Risk Management

Course number : DMP386E

Instructor : Dr. Kuniyoshi Takeuchi

Term / Time : Fall through Spring

1 Course Description

This course aims at consolidating the material covered in Course No. DMP380E “IFRM(1) Basic Concepts of IRBM, IFRM & Global Trends”, DMP381E “IFRM(2) Non-structural Measures & Community Defense” and DMP382E “IFRM(3) IRBM & Structural Measures”.

Exercises related to each topic will be given to the students and they will be discussed and explained. It also includes field survey.

Students performance at these exercises will be counted toward their grades.

2 Course Outline (Course Topics)

Week

- 1 : Practice on River Channel Planning (1)
- 2 : Practice on River Channel Planning (2)
- 3 : Practice on River Channel Planning (3)
- 4 : Practice on River Channel Planning (4)
- 5 : Practice on River Channel Planning (5)
- 6 : Practice on River Channel Planning (6)
- 7 : Practice on River Channel Planning (7)
- 8 : Practice on River Channel Planning (8)
- 9 : Practice on River Channel Planning (9)
- 10 : Practice on River Channel Planning (10)
- 11 : Practice on River Channel Planning (11)
- 12 : Project Assessment (1)
- 13 : Project Assessment (2)
- 14 : Flood control planning (1)
- 15 : Flood control planning (2)

3 Grading

Class participation(40%), Reports(60%)

4 Textbooks

4-1 Required

4-2 Others

Subject Practice on Hazard Mapping & Evacuation Planning

Course number : DMP387E

Instructor : Mr. Shigenobu Tanaka

Term / Time : Fall through Spring

1 Course Description

This course aims at consolidating the material covered in Course No. DMP383E “Hazard Mapping & Evacuation Planning”.

Exercises related to each topic will be given to the students and they will be discussed and explained. It also includes field survey.

Students performance at these exercises will be counted toward their grades.

2 Course Outline (Course Topics)

Week

- 1 : Inundation analysis (1)
- 2 : Inundation analysis (2)
- 3 : Inundation analysis (3)
- 4 : Inundation analysis (4)
- 5 : Mapping and GIS (1)
- 6 : Mapping and GIS (2)
- 7 : Mapping and GIS (3)
- 8 : Mapping and GIS (4)
- 9 : Town Watching (1)
- 10 : Town Watching (2)
- 11 : Town Watching (3)
- 12 : Town Watching (4)
- 13 : Town Watching (5)
- 14 : Town Watching (6)
- 15 : Town Watching (7)

3 Grading

Active participation (40%), Reports (30%), Final Exam (30%)

If a report is late for the deadline, it will be not evaluated.

4 Textbooks

4-1 Required

4-2 Others

Subject Practice on Sustainable Reservoir Development & Management

Course number : DMP388E

Instructor : Dr. Norihisa Matsumoto

Term / Time : Fall through Spring

1 Course Description

This course aims at consolidating the material covered in Course No. DMP384E “Sustainable Reservoir Development & Management”.

Exercises related to each topic will be given to the students and they will be discussed and explained. It also includes field survey.

Students performance at these exercises will be counted toward their grades.

2 Course Outline (Course Topics)

Week

- 1 . On-sight Survey for Dam Construction Site (Isawa Dam) (1)
- 2 . On-sight Survey for Dam Construction Site (Isawa Dam) (2)
- 3 . On-sight Survey for Dam Construction Site (Isawa Dam) (3)
- 4 . On-sight Survey for Dam Construction Site (Isawa Dam) (4)
- 5 . On-sight Survey for Dam Construction Site (Isawa Dam) (5)
- 6 . Field Survey on Dam Administration (Kawaji Dam, Ikari Dam) (1)
- 7 . Field Survey on Dam Administration (Kawaji Dam, Ikari Dam) (2)
- 8 . Field Survey on Dam Administration (Kawaji Dam, Ikari Dam) (3)
- 9 . Field Survey on Dam Administration (Kawaji Dam, Ikari Dam) (4)
- 1 0 . Practice on Dam Design (1)
- 1 1 . Practice on Dam Design (2)
- 1 2 . Practice on Dam Design (3)
- 1 3 . Practice on Dam Design (4)
- 1 4 . Application for other countries (1)
- 1 5 . Application for other countries (2)

3 Grading

Class participation (30%) 、 Report and Final examination (70%)

If you miss the deadline for reports, your reports will only be evaluated for a certain percentage of what they are supposed to be:

Up to seven days: 70%

Eight days or longer: 50%

4 Textbooks

4-1 Required

4-2 Others

Subject Practice on Control Measures for Landslide & Debris Flow

Course number : DMP389E

Instructor : Dr. Shun Okubo

Term / Time : Fall through Spring

1 Course Description

This course aims at consolidating the material covered in Course No. DMP385E “Control Measures for Landslide & Debris Flow”.

Exercises related to each topic will be given to the students and they will be discussed and explained. It also includes field survey.

Students performance at these exercises will be counted toward their grades.

2 Course Outline (Course Topics)

Week

1 . On-sight Survey for Sabo/Landslide Projects (1)

2 . On-sight Survey for Sabo/Landslide Projects (2)

3 . On-sight Survey for Sabo/Landslide Projects (3)

4 . On-sight Survey for Sabo/Landslide Projects (4)

5 . On-sight Survey for Sabo/Landslide Projects (5)

6 . On-sight Survey for Sabo/Landslide Projects (6)

7 . On-sight Survey for Sabo/Landslide Projects (7)

8 . On-sight Survey for Sabo/Landslide Projects (8)

9 . On-sight Survey for Sabo/Landslide Projects (9)

1 0 . Training of Development of Procedures for Sediment Disaster Warning and Evacuation (1)

1 1 . Training of Development of Procedures for Sediment Disaster Warning and Evacuation (2)

1 2 . Training of Development of Procedures for Sediment Disaster Warning and Evacuation (3)

1 3 . Training of Development of Procedures for Sediment Disaster Warning and Evacuation (4)

1 4 . Application of Sabo/Landslide Projects to Overseas Countries (1)

1 5 . Application of Sabo/Landslide Projects to Overseas Countries (2)

3 Grading

Class participation (30%) A Report and Final examination (70%)

4 Textbooks

4-1 Required

4-2 Others

Reference 6

List of Curriculum

Curriculum of Disaster Management Policy Program (Water-related Risk Management Course)

Lecture Number	(1) Hydrological Observation, Modeling & Forecasting	(2) Hydraulics	(3) Introduction to International Cooperation	(4) IFRM(1) Basic Concepts of IFRM, IFRM & Global Trends	(5) IFRM(2) Non-structural Measures & Community Defense
	DMP281E	DMP282E	DMP283E	DMP380E	DMP381E
Lecturer	Prof. Amithirigala Withanelage JAYAWARDENA	Prof. Tadaharu Ishikawa	Prof. Mikio Ishiwatari	Prof. Kuniyoshi Takeuchi	Prof. Kuniyoshi Takeuchi
Period	Fall through Winter	Fall through Winter	Fall through Winter	Fall	Fall through Winter
1	Processes in the hydrological cycle and their observations	Framework fundamental equation	International cooperation of JICA	Outline of integrated flood risk management (1)	Outline of Non-structural measures & Community defense
2	Remote sensing of precipitation; satellite observation	Equation for 1-dimension flow	International cooperation in disaster mitigation	Outline of integrated flood risk management (2)	Institutional framework
3	Measurement of runoff; rating curve	Roughness of channel and normal depth	Outline of local disaster prevention plan	Global trends of water-related disasters	Flood preparedness (1)
4	Statistical analysis of rainfall data; intensity-duration-frequency curves	Critical depth, Subcritical flow, Supercritical flow	Gender & disaster prevention (1)	Basic concepts of IFRM	Flood preparedness (2)
5	Stochastic analysis of rainfall data; time series analysis; rainfall prediction (1)	Quiz	Gender & disaster prevention (2)	Flood plain management	Education
6	Stochastic analysis of rainfall data; time series analysis; rainfall prediction (2)	Tour of laboratory	Project cycle management (1)	Lessons from the past flood	Emergency response
7	Peak flow estimation; rational method	Over flow and jump flow	Project cycle management (2)	Japanese experiences	Recovery & Rehabilitation
8	Hydrograph prediction; unit hydrograph methods	Gradually varied flow (1)	Project cycle management (3)	Global trends (1)	Human action and social psychology
9	Rainfall-runoff modeling; lumped approach (1)	Gradually varied flow (2)	Project cycle management (4)	Global trends (2)	Early warning (1)
10	Rainfall-runoff modeling; stochastic approach (2)	Unsteady flow	Project cycle management (5)	International activities	Early warning (2)
11	Rainfall-runoff modeling; distributed approach (3)	Multi-crossed channel	Project cycle management (6)	Effects of climate change (1)	Community defense (1)
12	Rainfall-runoff modeling; data driven approach (4)	Junction flow and diversion flow	Project cycle management (7)	Effects of climate change (2)	Community defense (2)
13	Flood forecasting; Kalman filtering	Retarding basin	Project cycle management (8)	Project assessment (1)	Flood insurance
14	Future trends	Curved area and bar	Project cycle management (9)	Project assessment (2)	Forestation
15	Examination	Examination	Project cycle management (10)	Examination	Examination

Curriculum of Disaster Management Policy Program (Water-related Risk Management Course)

Lecture Number	(6) IFRM(3) IREM & Structural Measures DMP382E	(7) Hazard Mapping & Evacuation Planning DMP383E	(8) Sustainable Reservoir Development & Management DMP384E	(9) Control Measures for Landslide & Debris Flow DMP385E
Lecturer	Prof. Shoji FUKUOKA	Prof. Shigenobu TANAKA	Prof. Northisa Matsumoto	Prof. Shun Okubo
Period	Fall through Winter	Fall	Fall through Winter	Fall through Winter
1	Outline, planning and administration of rivers	Outline of flood hazard map	Outline of Dam Engineering	Outline of sediment-related disasters
2	River Design (1)	Evacuation Planning	Flood Control Plan	Introduction to sabo projects
3	River Design (2)	Inundation analysis (1)	Flood Control Operation	Countermeasures for sediment-related disasters
4	River Design (3)	Inundation analysis (2)	Water Resources Planning	Hazard mapping for sediment-related disasters
5	River Design (4)	Mapping and GIS	Planning of Multi-purpose Dam	Comprehensive sediment-related disaster measures
6	River Channel Planning (1)	Anticipated inundation area in Flood Hazard Map	Utilization of Dams	Countermeasures for earthquake-induced natural dams
7	River Channel Planning (2)	Latest technology for FHM (Hiachi)	Environmental Impact of Dams (1)	Sabo works in arid area and reforestation of degraded lands
8	River Channel Planning (3)	Application of AROS data for FHM	Environmental Impact of Dams (2)	Volcanic sabo works
9	River Channel Planning (4)	Topography of river and its alluvial plains	Sediment Management in Reservoirs (1)	Application of sabo works and landslide countermeasures to overseas countries
10	River Channel Planning (5)	Dissemination and Utilization of FHM	Sediment Management in Reservoirs (2)	Introduction of landslides
11	River Management (1)	Town Watching (1)	Dam Construction (1)	Characteristics and topography of landslides
12	River Management (2)	Town Watching (2)	Dam Construction (2)	Stability analysis for landslide
13	Integrated River Basin Management (1)	Flood Hazard Map around the World	Dam Management	Survey and emergency response for landslide
14	Integrated River Basin Management (2)	Discussion	Effective Use of Existing Dams	Maintenance measures for roads and reservoirs in landslide areas
15	Examination	Examination	Roles of Dams in 21st Century	Permanent measures for landslide damage reduction

Curriculum of Disaster Management Policy Program (Water-related Risk Management Course)

Lecture Number	Practice on Hydrological Observation, Modeling & Forecasting	Practice on Hydraulics	Practice on Integrated Flood Risk Management
	DMP284E	DMP285E	DMP386E
Lecturer	Prof. Amithirigala Withanelage JAYAWARDENA	Prof. Tadaharu Ishikawa	Prof. Kuniyoshi Takeuchi
Period	Fall through Spring	Fall through Spring	Fall through Spring
1	Rating curve Lecture Lecturer Prof. Jaya, ICHARM	Framework of fundamental equation Lecture Lecturer Dr. Osti, ICHARM	Practice on River Channel Planning (1) Lecture Lecturer Dr. Hattori, NILIM
2	Intensity-duration-frequency curves Lecture Lecturer Prof. Jaya, ICHARM	Gradually varied flow (2) Lecture Lecturer Dr. Osti, ICHARM	Practice on River Channel Planning (2) Lecture Lecturer Dr. Hattori, NILIM
3	Probability distribution; fitting; goodness of fit Lecture Lecturer Prof. Jaya, ICHARM	Equation for 1-dimension flow Lecture Lecturer Dr. Osti, ICHARM	Practice on River Channel Planning (3) Lecture Lecturer Dr. Hattori, NILIM
4	Stochastic modeling - Time series analysis and prediction (1) Lecture Lecturer Prof. Jaya, ICHARM	Gradually varied flow (3) Lecture Lecturer Dr. Osti, ICHARM	Practice on River Channel Planning (4) Lecture Lecturer Dr. Hattori, NILIM
5	Stochastic modeling - Time series analysis and prediction (2) Lecture Lecturer Prof. Jaya, ICHARM	Roughness of channel and normal depth Lecture Lecturer Dr. Osti, ICHARM	Practice on River Channel Planning (5) Lecture Lecturer Dr. Hattori, NILIM
6	Peak flow estimation Lecture Lecturer Prof. Jaya, ICHARM	Unsteady flow (1) Lecture Lecturer Dr. Osti, ICHARM	Practice on River Channel Planning (6) Lecture Lecturer Dr. Hattori, NILIM
7	Derivation of unit hydrograph and Synthetic unit hydrographs Lecture Lecturer Prof. Jaya, ICHARM	Critical depth, Subcritical flow, Supercritical flow (1) Lecture Lecturer Dr. Osti, ICHARM	Practice on River Channel Planning (7) Lecture Lecturer Dr. Watanabe, PWRI
8	Hands on practice on typical rainfall-runoff models (1) Lecture Lecturer Prof. Jaya, ICHARM	Unsteady flow (2) Lecture Lecturer Dr. Osti, ICHARM	Practice on River Channel Planning (8) Lecture Lecturer Dr. Watanabe, PWRI
9	Hands on practice on typical rainfall-runoff models (2) Lecture Lecturer Prof. Jaya, ICHARM	Critical depth, Subcritical flow, Supercritical flow (2) Lecture Lecturer Dr. Osti, ICHARM	Practice on River Channel Planning (9) Lecture Lecturer Dr. Watanabe, PWRI
10	Hands on practice on typical rainfall-runoff models (3) Lecture Lecturer Prof. Jaya, ICHARM	Multi-crossed channel (1) Lecture Lecturer Dr. Osti, ICHARM	Practice on River Channel Planning (10) Lecture Lecturer Dr. Watanabe, PWRI
11	Hands on practice on typical rainfall-runoff models (4) Lecture Lecturer Prof. Jaya, ICHARM	Over flow and jump flow (1) Lecture Lecturer Dr. Osti, ICHARM	Practice on River Channel Planning (11) Lecture Lecturer Dr. Watanabe, PWRI
12	Flood forecasting using Kalman Filter Lecture Lecturer Prof. Jaya, ICHARM	Multi-crossed channel (2) Lecture Lecturer Dr. Osti, ICHARM	Project Assessment (1) Lecture Lecturer Mr. Wakigawa, JICE
13	Quiz Lecture Lecturer Prof. Jaya, ICHARM	Over flow and jump flow (2) Lecture Lecturer Dr. Osti, ICHARM	Project Assessment (2) Lecture Lecturer Mr. Wakigawa, JICE
14	Supplementary Class (1) Lecture Lecturer Prof. Jaya, ICHARM	Junction flow and diversion flow Lecture Lecturer Dr. Osti, ICHARM	Flood control planning (1) Lecture Lecturer Mr. Imbe, ARSIT
15	Supplementary Class (2) Lecture Lecturer Prof. Jaya, ICHARM	Gradually varied flow (1) Lecture Lecturer Dr. Osti, ICHARM	Flood control planning (2) Lecture Lecturer Mr. Imbe, ARSIT

Curriculum of Disaster Management Policy Program (Water-related Risk Management Course)

Lecture	Practice on Hazard Mapping & Evacuation Planning	Practice on Sustainable Reservoir Development & Management	Practice on Control Measures for Landslide & Debris Flow
Number	DMP387E	DMP388E	DMP389E
Lecturer	Prof. Shigenobu TANAKA	Prof. Norihisa Matsumoto	Prof. Shun Okubo
Period	Fall through Spring	Fall through Spring	Fall through Spring
	Lecture	Lecture	Lecture
1	Inundation analysis (1) Dr. Osti, ICHARM	Practice on Design (1) Mr. Iwashita, PWRI	Sediment Hazard Mapping Training (1) Mr. Takanashi, Sabo Frontier Foundation
2	Inundation analysis (2) Dr. Osti, ICHARM	Practice on Design (2) Mr. Sato, PWRI	Sediment Hazard Mapping Training (2)
3	Inundation analysis (3) Dr. Osti, ICHARM	Practice on Design (3) Mr. Sakurai, PWRI	Sediment Hazard Mapping Training (3)
4	Inundation analysis (4) Dr. Osti, ICHARM	Practice on Design (4)	Sediment Hazard Mapping Training (4)
5	Mapping and GIS (1) Dr. Hapu, ICHARM	Application for other countries (1) Dr. Matsumoto, Japan Dam Engineering Center	Application of Sabo/Landslide Projects to Overseas Countries Dr. Ikeya, SABO Technical Center
6	Mapping and GIS (2) Dr. Hapu, ICHARM	Application for other countries (2)	Application of Sabo/Landslide Projects to Overseas Countries Mr. Koga, NILIM
7	Mapping and GIS (3) Dr. Hapu, ICHARM	Field Survey on Dam Construction Site (Obara Dam)	On-sight Survey for Degraded land Afforestation/Reforestation (1): Hillside Works at Mt. Ohnagi
8	Mapping and GIS (4) Dr. Hapu, ICHARM		On-sight Survey for Degraded land Afforestation/Reforestation (2): Hillside Works at Mt. Ohnagi
9	Town Watching (1) Prof. Ogawa, Fujitokoha Univ.	Field Survey on Dam Administration (Nukui Dam)	On-sight Survey for Degraded land Afforestation/Reforestation (3): Hillside Works at Mt. Ashio
10	Town Watching (2) Prof. Ogawa, Fujitokoha Univ.		On-sight Survey for Earthquake Sabo/Yuzawa Sabo Office, MLIT (1): Imogawa River
11	Town Watching (3) Prof. Ogawa, Fujitokoha Univ.	Field Survey on Dam Administration (Kawaji Dam, Itawa Dam)	On-sight Survey for Earthquake Sabo, (2): Imogawa River
12	Town Watching (4) Prof. Ogawa, Fujitokoha Univ.		On-sight Survey for River System Sabo, (1): Joganji-gawa River
13	Town Watching (5) Prof. Ogawa, Fujitokoha Univ.	Field Survey on Dam Construction Site (Isawa Dam)	On-sight Survey for River System Sabo, (2): Joganji-gawa River
14	Town Watching (6) Prof. Ogawa, Fujitokoha Univ.		On-sight Survey for River System Sabo, (3): Joganji-gawa River
15	Town Watching (7) Prof. Ogawa, Fujitokoha Univ.		On-sight Survey for River System Sabo, (4): Joganji-gawa River

Reference 7

Original Certificate

National Graduate Institute for Policy Studies

Based on the recommendation of the Faculties of
the National Graduate Institute for Policy Studies, and
the Public Works Research Institute,

the National Graduate Institute for Policy Studies
hereby confers the degree

of

Master of Disaster Management

upon

Student name

for having successfully completed all of the requirements of the
Disaster Management Policy Program

on this, the seventeenth day of September, 2008

President
National Graduate Institute for Policy Studies

Director
International Centre for Water Hazard and Risk Management,
Public Works Research Institute

Certificate

No. 001

This is to certify that

*enrolled for the Water-related Disaster Management Course at
the International Centre for Water Hazard and Risk Management (ICHARM)
under the auspices of UNESCO during October 2007- September 2008
and completed the course successfully on this, the 18th of September, 2008.*

Kuniyoshi Takeuchi
Director of ICHARM

Tadahiko Sakamoto
Chief Executive of PWRI

*International Centre for Water Hazard and Risk Management (ICHARM)
under the auspices of UNESCO*

Public Works Research Institute (PWRI)

Reference 8

List of Lecturers

List of Lecturers for 2007-2008 Water-related Risk Management Course

	Lecture	Name	Affiliation	Position
1	Disaster Management Policy	Shigeru Morichi	National Graduate Institute for Policy Studies (GRIPS)	Professor
2	Disaster Risk Management	Kenji Okazaki	National Graduate Institute for Policy Studies (GRIPS)	Professor
3	Hydrological Observation, Modeling & Forecasting	Amithirigala Widhanelage JAYAWARDENA	International Centre for Water Hazard and Risk Management (ICHARM)	Research & Training Advisor
4		Kazuhiko Fukami	International Centre for Water Hazard and Risk Management (ICHARM)	Team Leader
5	Hydraulics	Tadaharu Ishikawa	Tokyo Institute of Technology	Professor
6	Introduction to International Cooperation	Mikio Ishiwatari	Japan International Cooperation Agency (JICA)	Senior Advisor
7		Youko Suzuki	Japan International Cooperation Agency (JICA)	Senior Advisor
8		Takeaki Tomioka	IC Net Limited	Senior Consultant
9	IFRM(1) Basic Concepts of IRBM, IFRM & Global Trends	Kuniyoshi Takeuchi	International Centre for Water Hazard and Risk Management (ICHARM)	Director
10		Junichi Yoshitani	International Centre for Water Hazard and Risk Management (ICHARM)	Team Leader
11		Hutoshi Nakamura	Graduate School of Agriculture, Hokkaido University	Professor
12		Mikiyasu Nakayama	Graduate School of Frontier Sciences, the University of Tokyo	Professor
13		Hisaya Sawano	Japan Institute of Construction Engineering	Sub manager
14		Taikan Oki	Institute of Industrial Science, the University of Tokyo	Professor
15		Katsumi Wakigawa	Japan Institute of Construction Engineering	Sub manager
16	IFRM(2) Non-structural Measures & Community Defense	Katsuhito Miyake	International Centre for Water Hazard and Risk Management (ICHARM)	Chief Researcher
17		Minoru Kuriki	Foundation of River & Basin Integrated Communications	Manager
18		Akira Kitagawa	Foundation of River & Basin Integrated Communications	Vice Executive
19		Tadahiko Nakao	Foundation of River & Basin Integrated Communications	Executive
20		Atsushi Yoshii	Civil Engineering Research Institute for Cold Region (CERI)	Group Leader
21		Hideki Kamei	Ise City	Vice Mayor
22		Haruo Hayashi	Disaster Prevention Research Institute, Kyoto University	Professor
23		Hiroaki Tsubokawa	National Research Institute for Earth Science and Disaster Prevention	Guest Researcher
24		Yuichi Onda	Institute of Geoscience, University of Tsukuba	Associate Professor
25	IFRM(3) IRBM & Structural Measures	Shoji Fukuoka	Chuo University	Professor
26		Atsushi Hattori	River Department, National Institute for Land and Infrastructure Management (NILIM)	Senior Researcher
27		Yasuharu Watanabe	Civil Engineering Research Institute for Cold Region (CERI)	Team Leader
28		Masahiro Imbe	Association for Rainwater Storage and Infiltration Technology	Executive
29	Flood Hazard Mapping & Evacuation Planning	Shigenobu Tanaka	International Centre for Water Hazard and Risk Management (ICHARM)	Team Leader
30		Masatomo Umitsu	Graduate School of Environmental Studies, Nagoya University	Professor
31		Meulen Frank	UNESCO Institute for Water Education (IHE)	Professor
32		Yujiro Ogawa	Fuji Tokoha University	Professor
33		Osti Rabindra	International Centre for Water Hazard and Risk Management (ICHARM)	Researcher
34		Prasanth Hapuarachchi	International Centre for Water Hazard and Risk Management (ICHARM)	Researcher
35	Sustainable Reservoir Development & Management	Norihisa Matsumoto	Japan Dam Engineering Center	Advisor
36		Tadahiko Sakamoto	Public Works Research Institute	Chief Executive
37		Noriaki Hakoishi	Hydraulic Engineering Research Group, Public Works Research Institute	Team Leader
38		Hitoshi Yoshida	Hydraulic Engineering Research Group, Public Works Research Institute	Group Leader
39		Hitoshi Umino	Hydraulic Engineering Research Group, Public Works Research Institute	Senior Researcher
40		Hideaki Kawasaki	National Institute for Land and Infrastructure Management (NILIM)	Chief Researcher
41		Kunihiko Amano	Water Environment Research Group, Public Works Research Institute	Team Leader
42		Tetsuya Sumi	Graduate School of Management, Kyoto University	Associate Professor
43		Yoshikazu Yamaguchi	Hydraulic Engineering Research Group, Public Works Research Institute	Team Leader
44		Syui Takasu	Japan Dam Engineering Center	Executive
45	(Exercise)	Tomoya Iwashita	Hydraulic Engineering Research Group, Public Works Research Institute	Senior Researcher
46		Hiroyuki Sato	Hydraulic Engineering Research Group, Public Works Research Institute	Senior Researcher
47		Toshiyuki Sakurai	Hydraulic Engineering Research Group, Public Works Research Institute	Senior Researcher
48	Control Measures for Landslide & Debris Flow	Shun Okubo	Japan Sabo Association	Chief Executive
49		Yoshiharu Ishikawa	Tokyo University of Agriculture and Technology	Professor
50		Kazuyuki Takanashi	Sabo Frontier Foundation	Executive
51		Nobutomo Osanai	National Institute for Land and Infrastructure Management (NILIM)	Team Leader
52		Hiroshi Ikeya	Sabo Technical Center	Chief Executive
53		Takashi Yamada	Graduate School of Agriculture, Hokkaido University	Associate Professor
54		Masayuki Watanabe	International Institute for Social Development and Cooperation	Chief
55		Hiroyuki Yoshimatsu	Institute of Slope Technology	Chief
56		Mio Kasai	Erosion and Sediment Control Research Group, Public Works Research Institute	Researcher
57		Ryosuke Tsunaki	Sabo Technical Center	Manager
58		Kazunori Fujisawa	Erosion and Sediment Control Research Group, Public Works Research Institute	Team Leader
59		Kouji Ishida	Erosion and Sediment Control Research Group, Public Works Research Institute	Senior Researcher
60	(Exercise)	Shozo Koga	National Institute for Land and Infrastructure Management (NILIM)	Director
61		Hideki Terada	Erosion and Sediment Control Research Group, Public Works Research Institute	Group Leader

Reference 9

Course Schedule

Course Schedule of 2007-2008 Disaster Management Policy Program (Water-related Risk Management Course)

Lecture (Lecturer)

(1) Hydrological Observation, Modeling & Forecasts (Prof. Jaya)
(2) Hydraulics (Prof. Ishikawa)
(3) Introduction to International Cooperation (Prof. Ishiwatari)
(4) IFRM(1) Basic Concepts of IFRM, IFRM & Global Trends (Prof. Takeuchi)
(5) IFRM(2) Non-structural Measures & Community Defense (Prof. Takeuchi)
(6) IFRM(3) IFRM & Structural Measures (Prof. Fukuoka)

(7) Hazard Mapping & Evacuation Planning (Prof. Tanaka)
(8) Sustainable Reservoir Development & Management (Prof. Matsumoto)
(9) Control Measures for Landslide & Debris Flow (Prof. Okubo)
(10) Disaster Mitigation Policy (Prof. Morichi)
(11) Disaster Risk Management (Prof. Okazaki)

Exercise (Lecturer)

(1)P Practice on Hydrological Observation, Modeling & Forecasts (Prof. Jaya)
(2)P Practice on Hydraulics (Prof. Ishikawa)
(6)P Practice on Integrated Flood Risk Management (Prof. Fukuoka)

(7)P Practice on Hazard Mapping & Evacuation Planning (Prof. Tanaka)
(8)P Practice on Sustainable Reservoir Development & Management (Prof. Matsumoto)
(9)P Practice on Control Measures for Landslide & Debris Flow (Prof. Okubo)

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
	30	10/1	2	3	4	5	6
1st class 9:00-10:30							
2nd class 10:45-12:15		9:45-18:00	10:00-17:00	10:00-17:15	9:30-14:00 Entrance Ceremony at GRIPS	10:00-12:00	
3rd class 13:15-14:45		Orientation at JICA TSUKUBA	Orientation at JICA TSUKUBA			Orientation at ICHARM	
4th class 15:00-16:30					16:30-18:00 Entrance Ceremony at ICHARM		
7		8	9	10	11	12	13
1st class 9:00-10:30			Orientation	(1)-1 Processes in the hydrological cycle and their observations	Presentation of Inception Report (15minutes for each participants)	(4)-3 Global trends of water-related disasters	Ass. Prof. Yoshitani
2nd class 10:45-12:15			(4)-1 Outline of integrated flood risk management (1)	(2)-1 Framework of fundamental equation		(4)-4 Basic concepts of IFRM	Prof. Takeuchi
3rd class 13:15-14:45			(4)-2 Outline of integrated flood risk management (2)	(2)-2 Equation for 1-dimension flow	(2)P-1 Dr. Oshi	(5)-1 Outline of Non-structural measures & Community defense	Prof. Takeuchi
4th class 15:00-16:30					(2)P-2 Dr. Oshi	(2)P-3	Dr. Oshi
14		15	16	17	18	19	20
1st class 9:00-10:30	(5)-2 Institutional framework	Ass. Prof. Miyake	Statistical analysis of rainfall data, intensity-duration-	(1)P-1 Prof. Jaya	(4)-5 Flood plain management	(6)-1 Outline, planning and administration of rivers	Prof. Fukuoka
2nd class 10:45-12:15	Remote sensing of precipitation, satellite observation	Prof. Jaya	(1)-4 data, intensity-duration-	(2)-3 Roughness of channel and normal depth	(1)-6 Stochastic analysis of rainfall data, time series analysis;	(6)-2 River Design(1)	Prof. Fukuoka
3rd class 13:15-14:45	Measurement of runoff, rating curve	Prof. Jaya	(1)-5 Stochastic analysis of rainfall data, time series analysis;	(2)-4 Critical depth, Subcritical flow, Supercritical flow	(2)P-7 Dr. Oshi	(2)P-9	Dr. Oshi
4th class 15:00-16:30		Dr. Oshi	(2)P-6		(2)P-8	(2)P-10	Dr. Oshi
21		22	23	24	25	26	27
1st class 9:00-10:30		Peak flow estimation, rational method	(6)-3 River Design (2)	(8)-1 Outline of Dam Engineering	Outline of sediment-related disasters	(1)P-4	Prof. Jaya
2nd class 10:45-12:15	Hydrograph prediction, unit hydrograph methods	Prof. Jaya	(6)-4 River Design (3)	Dr. Hakuishi	(9)-2 Introduction to sabo projects	(1)P-5	Prof. Jaya
3rd class 13:15-14:45	Lessons from the past flood	Prof. Takeuchi	(4)-7 Japanese experiences	Dr. Hakuishi	(9)-3 Countermeasures for sediment-related disasters	(4)-9 Global trends (2)	Prof. Nakayama
4th class 15:00-16:30		Prof. Jaya	(1)P-3	Quiz	Discussion on Individual Study	Discussion on Individual Study	

		28	29		30		31		11/1		2		3				
1st class 9:00-10:30	(6)-5	River Design (4)	Prof. Fukuoka	Outline of flood hazard map		Prof. Tanaka	(7)-1	Exercise on Maps and GIS	Dr. Hapu	(7)-9	Town Watching (1) Orientation for 1st Town Watching	Mr. Tokoka	(7)-11	Group Discussion of 1st Town Watching	ICHARM		
2nd class 10:45-12:15	(6)-6	River Channel Planning (1)	Prof. Fukuoka	Mapping and GIS		Dr. Hapu	(7)-5	Exercise on Maps and GIS	Dr. Hapu	(7)-7	Exercise on Maps and GIS	Dr. Hapu	(7)-9	Exercise on Maps and GIS	Dr. Hapu		
3rd class 13:15-14:45		Medical Checkup by JICA		Exercise on Maps and GIS		Dr. Hapu	(7)-5	Exercise on Maps and GIS	Dr. Hapu	(Presentation of Country Report by FHM Course Participants)		ICHARM	(7)-3	Inundation Analysis (1)	Dr. Osi		
4th class 15:00-16:30		Medical Checkup by JICA		Opening Ceremony 16:30- Reception Party at ICHARM 17:15-									(7)-10	Inundation Analysis (1)	Dr. Osi		
4	5		6		7		8		9		10						
1st class 9:00-10:30	(7)-4	Inundation Analysis (2)	Dr. Osi	ICHARM Symposium		(7)-3	Inundation Analysis (3)	Dr. Osi	(7)-4	Inundation Analysis (4)	Dr. Osi	(1)-7	Prof. Jaya				
2nd class 10:45-12:15	(7)-6	Anticipated Inundation Area in FHM	Dr. Osi			(7)-3	Inundation Analysis (3)	Dr. Osi	(5)-8	Human behavior and social psychology	Prof. Hayashi	(1)-3	Prof. Jaya				
3rd class 13:15-14:45	(7)-2	Inundation Analysis (2)	Dr. Osi			(7)-4	Inundation Analysis (4)	Dr. Osi	(1)-9	Rainfall-runoff modeling; lumped approach (1)	Prof. Jaya	(1)-11	Rainfall-runoff modeling; distributed approach (3)	Prof. Jaya			
4th class 15:00-16:30						(7)-4	Inundation Analysis (4)	Dr. Osi	(1)-10	Rainfall-runoff modeling; stochastic approach (2)	Prof. Jaya	(1)-12	Rainfall-runoff modeling; data driven approach (4)	Prof. Jaya			
11	12		13		14		15		16		17						
1st class 9:00-10:30	(2)-6	Tour of ICHARM laboratory		move to Ise City			(7)-12	Town Watching (4)	Prof. Ogawa	(7)-12	Town Watching (2)	Prof. Ogawa					
2nd class 10:45-12:15	(7)-9	Topography of river and its alluvial plains	Prof. Umitsu	Field Survey along Miya River		(5)-6,7	Emergency response Recovery & Rehabilitation	Mr. Kamei	Prof. Ogawa	(7)-13	Town Watching (5)	Prof. Ogawa	Presentation and Discussion				
3rd class 13:15-14:45	(7)-13	FHM around the world	Prof. Meulen			(7)-11	Town Watching (1)	ICHARM	(7)-14	Town Watching (6)	Prof. Ogawa	move to Tsukuba City					
4th class 15:00-16:30	(5)-5	Education	Dr. Yoshi														
18	19		20		21		22		23		24						
1st class 9:00-10:30	(7)-15	Town Watching (7) Preparation and General Discussion	ICHARM	Exercise on Flood Hazard Mapping		Dr. Osi and Mr. Tokoka	(7)-7	Trial of IFAS	Mr. Sugura	(7)-7	Latest Technology for FHM	Mr. Mural and Yamaguchi (HITACHI)					
2nd class 10:45-12:15	(7)-8	Application of ALOS Data for FHM	Mr. Kai (JAXA)	Exercise on Flood Hazard Mapping		Dr. Osi and Mr. Tokoka	Field Tour in Niimiya Reference Library		Prof. Tanaka	Latest Technology for FHM (Exercise)							
3rd class 13:15-14:45	(7)-2	Evacuation Planning	Prof. Tanaka	Exercise on Flood Hazard Mapping		Mr. Sawano											
4th class 15:00-16:30																	
25	26		27		28		29		30		12/1						
1st class 9:00-10:30	(1)-9		Prof. Jaya	Exercise on Flood Hazard Mapping		Dr. Osi and Mr. Tokoka	(Preparation for Individual Study)			(7)-14	Discussion	Prof. Tanaka					
2nd class 10:45-12:15	(1)-10		Prof. Jaya	Exercise on Flood Hazard Mapping		Dr. Osi and Mr. Tokoka	(Preparation for Individual Study)			(7)-15	Examination						
3rd class 13:15-14:45	(1)-11		Prof. Jaya	Exercise on Flood Hazard Mapping		Dr. Osi and Mr. Tokoka	(9)-4 Hazard mapping for sediment-related disasters		Dr. Takarashi								
4th class 15:00-16:30		(Preparing Proposal Report)		Exercise on Flood Hazard Mapping		Dr. Osi and Mr. Tokoka	(7)-10	FHM Dissemination and Utilization of	Prof. Tanaka	Closing Ceremony and Party at JICA							
2	3		4		5		6		7		8						
1st class 9:00-10:30						(2)-7	Over flow and jump flow	Prof. Ishikawa	Presentation of Individual Study (30minutes for each participants)		Presentation of Individual Study (30minutes for each participants)						
2nd class 10:45-12:15						(2)-8	Gradually varied flow (1)	Prof. Ishikawa	(5)-14	Forestation	Ass Prof. Onda		Presentation of Individual Study (30minutes for each participants)				
3rd class 13:15-14:45						(5)-3	Flood preparedness (1)	Dr. Nakao	Presentation of Individual Study (30minutes for each participants)								
4th class 15:00-16:30						(5)-4	Flood preparedness (2)	Dr. Nakao	(5)-11	Community defense (1)	Dr. Kikawa	Special Lecture by UNESCO 13:00-15:00					
9	10		11		12		13		14		15						
1st class 9:00-10:30	(1)-13	Flood forecasting; Kalman filtering	Prof. Jaya	(2)-13	Flood insurance	Dr. Tsubokawa	(1)-13	Prof. Jaya	(2)-15	Dr. Osi							
2nd class 10:45-12:15	(1)-14	Future trends	Prof. Jaya	(2)-14	Global trends (1)	Prof. Takeuchi	(6)-3	Dr. Hatori	(2)-16	Dr. Osi							
3rd class 13:15-14:45				(4)-11	Effects of climate change (1)	Prof. Oki	(6)-4	Dr. Hatori	(5)-9	Early warning (1)	Mr. Fukami						
4th class 15:00-16:30				(4)-12	Effects of climate change (2)	Prof. Oki	(5)-12	Community defense (2)	Mr. Kuriki	(5)-10	Early warning (2)	Mr. Fukami					
16	17		18		19		20		21		22						
1st class 9:00-10:30	(2)-17		Dr. Osi	(4)-13	Project assessment (1)	Dr. Wakagawa	(4)-15	Examination	Examination								
2nd class 10:45-12:15	(9)-5	Comprehensive sediment-related disaster measures	Prof. Okubo	(4)-14	Project assessment (2)	Dr. Wakagawa	(8)-4	Water Resources Planning	Dr. Yoshida	(8)-5	Planning of Multi-purpose Dam	Mr. Umno					
3rd class 13:15-14:45	(6)-7	River Channel Planning (2)	Dr. Hatori	(6)-12		Dr. Wakagawa	Interim Evaluation Meeting				(9)-6	Countermeasures for earthquake-induced natural dams	Dr. Osanai				
4th class 15:00-16:30	(6)-8	River Channel Planning (3)	Dr. Hatori	(6)-13		Dr. Wakagawa	(2)-18	Dr. Osi	(2)-19								

November

December

January

Feb	17	18			19		20		21		22		23
	1st class 9:00-10:30	(9)-9	Application of sabo works and landslide countermeasures to landslides		(8)-8		(8)-11 Dam Construction (1)		(8)-14 Effective Use of Existing Dams		(9)-11 Characteristics and topography of landslides		Ms. Kasai
	2nd class 10:45-12:15	(9)-10	Introduction of landslides		(8)-8 (2)		(8)-12 Dam Construction (2)		(8)-15 Roles of Dams in 21st Century		(9)-12 Stability analysis for landslide		Dr. Tsunaki
	3rd class 13:15-14:45	(8)-7	Environmental Impact of Dams (1)		(8)-9		(8)-13 Dam Management		(8)-2 Gender (1)		(9)-13 Survey and emergency response for landslide		Dr. Fujisawa
	4th class 15:00-16:30				(8)-10				(8)-3 Gender (2)				
24	25			26		27		28		29		3/1	
1st class 9:00-10:30	(8P)-10	Practice on Dam Design (1)		(8)-9		(9)-14 Maintenance measures for roads and reservoirs in landslide		(8)-15 Examination		(8P)-14 Application for other countries		Dr. Mitumoto & Dr. Yamaguchi	
2nd class 10:45-12:15	(8P)-11	Practice on Dam Design (2)		(8P)-12		(8)-15 Permanent measures for landslide damage reduction		(8)-15		(8P)-15		Dr. Mitumoto & Dr. Yamaguchi	
3rd class 13:15-14:45				(8P)-13						(9P)-14 Application of Sabo/Landslide Projects to Overseas Countries		Dr. Ikeya	
4th class 15:00-16:30										(9P)-15		Dr. Ikeya	
2	3			4		5		6		7		8	
1st class 9:00-10:30	Project Cycle Management (1)			Project Cycle Management (2)		Project Cycle Management (3)		Project Cycle Management (4)		Supplementary Lecture of Hydrology (1)		Prof. Jaya	
2nd class 10:45-12:15										Supplementary Lecture of Hydrology (2)		Prof. Jaya	
3rd class 13:15-14:45													
4th class 15:00-16:30													
9	10			11		12		13		14		15	
1st class 9:00-10:30				(8)-11 River Management (1)		Field Survey in Chugoku Region		Field Survey in Chugoku Region		Field Survey in Chugoku Region		Field Survey	
2nd class 10:45-12:15				(8)-12 River Management (2)								In Kinki	
3rd class 13:15-14:45				Exam of Hydrology									
4th class 15:00-16:30													
16	17			18		19		20		21		22	
1st class 9:00-10:30	Field Survey												
2nd class 10:45-12:15													
3rd class 13:15-14:45													
4th class 15:00-16:30													
24	24			25		26		27		28		29	
1st class 9:00-10:30													
2nd class 10:45-12:15										Participation in presentation by Ms. Arai			
3rd class 13:15-14:45										Interim Evaluation Meeting			
4th class 15:00-16:30													
March		17			18		19		20		21		22
	1st class 9:00-10:30				(8)-11 River Management (1)		Prof. Fukuoka		Field Survey in Chugoku Region		Field Survey in Chugoku Region		Field Survey
	2nd class 10:45-12:15				(8)-12 River Management (2)		Prof. Fukuoka						In Kinki
	3rd class 13:15-14:45				Exam of Hydrology								
	4th class 15:00-16:30												
16	17			18		19		20		21		22	
1st class 9:00-10:30	Field Survey												
2nd class 10:45-12:15													
3rd class 13:15-14:45													
4th class 15:00-16:30													
23	24			25		26		27		28		29	
1st class 9:00-10:30													
2nd class 10:45-12:15										Participation in presentation by Ms. Arai			
3rd class 13:15-14:45										Interim Evaluation Meeting			
4th class 15:00-16:30													

Reference 10

Itineraries of Field Trip

Schedule of Field Trip in Mie Prefecture

Date	Time	Schedule
13th Nov.	9:07	Tsukuba Sta.
	12:33	Nagoya Sta.
	13:30-14:00	Kumodu River (Discontinuouse Levee)
	15:00-15:30	Upper Reach of Miya River (Slope Failure)
	16:30	Asanokan Hotel
14th	8:15-9:45	Ise Jingu Shrine
	10:00-10:30	Interview at Enza District on Disaster Prevention Activity
	13:00-15:00	Lecture by Vice Mayor Kamei
	15:00-15:30	Orientation (1) by ICHARM staff
	15:30-16:30	Discussion (1) in each group
	16:30-17:30	Presentation (1) in each group
	18:00	Asanokan Hotel
15th	8:30-9:30	Orientation (2) by Prof. Ogawa
	10:00-15:30	Town Watching in Ise City
	16:00-18:00	Discussion (2) in each group
16th	8:30-9:30	Discussion (3) in each group
	10:00-12:00	Presentation (2) in each group
	13:00-14:00	Interview on Disaster Prevention Activities in Higashi Oizu District
	14:00～	move back to Tsukuba

Water-related Disaster Management of Disaster Management Policy Program
Tentative Schedule of Field Trip in Chugoku Region
防災政策プログラム 水災害リスクマネジメントコース 中国地方 現地見学 行程表(案)

ICHARM, PWRI

12th March (WED)

7:53	ひたち野うしく駅	Hitachi-no-ushiku Sta.
↓ JR		
9:50	羽田空港第2ビル駅	Haneda Airport No.2 Sta.
11:05	羽田空港	Haneda Airport
↓ ANA813		
12:25	米子空港	Yonago Airport
13:00	米子空港	Yonago Airport
↓ Bus		
13:00-14:00	皆生海岸	Kaike Coast
↓ Bus		
14:45	江島大橋	Eshima Bridge
↓ Bus		
16:00-16:30	大橋川コミュニティセンター	Ohashi River Community Center
↓ Bus		
16:40-17:40	堀川遊覧	Sightseeing Horikawa by ship
↓ Bus		
17:55-18:25	宍道湖	Shinji Lake
↓ Bus		
19:10	ホテル(東横イン出雲市駅前)	Hotel (Toyoko-inn)

13th March (THU)

7:30	出発	Departure
↓ Bus		
7:50-8:50	出雲大社	Izumo Shrine
↓ Bus		
9:10-10:10	斐伊川放水路	Diversion of Hii River
↓ Bus		
11:50-13:50	奥出雲たたらと刀剣館	Museum on Iron and Sword
↓ Bus		
14:20-15:00	尾原ダム	Obara Dam
↓ Bus		
18:00	ホテル(ヴィアイン広島)	Hotel (Via Inn Hiroshima)

14th March (FRI)

8:50	出発	Departure
↓ Bus		
9:15-9:40	太田川河川事務所	Ootagawa River Office, MLIT
↓ Bus		
11:00-11:30	温井ダム	Nukui Dam
↓ Bus		
11:30-12:00	昼食	Lunch
↓ Bus		
12:25-12:35	津伏堰	Tsuhuse Weir
↓ Bus		
13:30-13:45	高瀬堰	Takase Weir
↓ Bus		
13:55-14:15	古川せせらぎ河川公園	Huru River Park
↓ Bus		
14:40-15:00	祇園水門	Gion Gate
↓ Bus		
15:30-15:40	高潮堤防	Storm Surge Levee

↓ Bus		
16:10-17:00	元安川親水テラス、原爆ドーム	Motoyasu River, A-Bomb Dome
↓ Bus		
18:28	広島駅	Hiroshima Sta.
↓ Nozomi 46 (Shinkansen)		
19:37	新神戸駅	Shinkoube Sta.
↓ Bus		
20:00	JICA兵庫	JICA Hyogo

15th March (SAT)

9:20	出発	Departure
↓ Walk		
9:30-10:30	人と防災未来センター	Disaster Reduction and Human Renovation Institution
↓ Walk		
11:08	阪神電車 岩屋駅	Iwaya Sta.
↓ Hanshin Railway, Osaka Subway		
11:57	大阪市営地下鉄 なんば駅	Namba Sta.
↓ Lunch & Walk		
13:20	太左衛門橋船着場	Tasaemon-bashi Port
↓ Ship (Sightseeing from a ship)		
14:00	大阪城港船着場	Osaka-jo Port
↓ Walk		
14:20-15:40	大阪城	Osaka Castle
↓ Walk		
16:00	京阪本線 京橋駅	Kyobashi Sta.
↓ Keihan Railway		
16:13	京阪本線 大和田駅	Owada Sta.
↓ Walk		
16:30-17:30	茨田の堤(日本最古の堤防)	Manda-no-Tsutsumi (the oldest levee in Japan)
↓ Walk		
17:42	京阪本線 大和田駅	Owada Sta.
↓ Hanshin Railway, Osaka Monorail		
18:18	大阪モノレール 阪大病院前	Handai-byouin Mae Sta.
↓ Walk or bus		
18:40	JICA大阪	JICA Osaka

16th March (SUN)

8:00	出発	Departure
↓ JICA Bus		
8:15	JR茨木駅	Ibaraki Sta.
8:29	JR茨木駅	Ibaraki Sta.
↓ JR		
8:57	JR京都駅	Kyoto Sta.
9:23	京都市営地下鉄 京都駅	Kyoto Sta.
↓ Subway		
9:40	京都市営地下鉄 蹴上駅	Keage Sta.
	琵琶湖疏水記念館・ 南禅寺・哲学の道	Lake Biwa Canal Museum, Nanzenji Temple, Philosophers' Path
18:26	京都駅	Kyoto Sta.
↓ Nozomi 72 (Shinkansen)		
20:46	東京駅	Tokyo Sta.
↓ JR		
22:19	ひたち野うしく	Hitachi-no-ushiku Sta.

Water-related Disaster Management of Disaster Management Policy Program
Tentative Schedule of Field Trip in Kanto Region

ICHARM, PWRI

【22nd April, 2008】

7:47 Hitachi-no-ushiku Sta. -> (JR, Tokyo Metro) ->

9:28 Hounan-cho (Marunouchi Line)

10:00-12:00 **Kanda River Underground diversion channel**

14:00-14:30 **Shukugawara Weir**

15:00-15:30 **Tsurumi River Multi-purpose Runoff Retardation Area**

16:00-16:30 **Kirigaoka Regulating Pond**

Around 17:00 Nagatsuda Sta. -> (Tokyu Line, JR) ->

Around 19:00 Hitachi-no-ushiku Sta.

【23rd April, 2008】

8:27 Hitachi-no-ushiku Sta. -> (JR) ->

9:46 Ryougoku Sta.

10:00-11:30 **Edo-Tokyo Museum**

13:30-18:10 **“International Seminar on Role of Dams”**

(Kousai Kaikan at Yotsuya)

18:30 Yotsuya Sta. -> (JR) -> 19:51 Hitachi-no-ushiku Sta.

Schedule of Field Trip in Kanto Region

ICHARM

【28th May, 2008 (Wed)】

7:00 Departure from TBIC TBIC 発
 7:30 Public Works Research Institute 土研本館玄関前
 ↓
 9:00～10:00 Watarase Retarding Basin 渡良瀬遊水地
 ↓
 11:00～12:00 Kinugawa Integrated Dam Control Office
 鬼怒川ダム統合管理事務所（宇都宮）
 ↓ (Lunch)
 14:00～16:00 Kawaji Dam Control Office, Ikari Dam Control Office
 川治ダム管理支所、五十里ダム管理支所
 ↓ (途中鬼怒川温泉駅で海野主研下車)
 16:30～ Nikko Toshogu Shrine 日光東照宮見学
 (stay at Utsunomiya 宇都宮泊（ホテルサンルート宇都宮）、内田主研合流)

【29th May, 2008 (Thu)】

7:00 Departure from Hotel
 ↓
 8:30～9:00 Nikko Sabo Work Office 日光砂防事務所（2 階会議室）
 ↓
 9:40～10:00 Kegon-no-taki Fall 華嚴の滝見学
 ↓
 10:10～11:00 Sabo Works on Nantai Mt. 大薙山腹工
 ↓
 12:00～14:30 Lunch at Akagane Park 銅親水公園にて昼食
 Sabo work in Ashio
 足尾砂防堰堤・足尾環境学習センター見学
 松木山腹工見学
 ↓
 16:30～17:15 Yattajima Observatory 八斗島観測所
 ↓
 20:00 Arrival at Tsukuba つくば着

Schedule of Field Trip in Hokuriku & Tohoku Region (9/8-11)

ICHARM

【8th September, 2008】

6:57 Hitachi-No-Ushiku Sta.
↓ Joban Line
7:59 Ueno Sta.
(transfer)
8:30 Ueno Sta.
↓ Shinkansen ("Toki 309")
9:59 Urasa Sta.
↓ Bus
10:30-13:30 **1: Sabo Works in Imo River (Yamakoshi District)**
Nakayama Tunnel (the longest tunnel dig by human power)
Natural dam in Higashi-Takezawa, Houses in the water,
↓ Bus Natural dam in Terano, etc.
15:00-16:30 **2: Shinano River Ohkousu Museum**
↓ Bus
19:00 Stay at Toyama City

【9th September, 2008】

9:10-14:45 **3: Sabo Works in Mt. Tateyama**
↓ "Kurobe-Tateyama Alpen Route" <http://www.alpen-route.com/english/index.html>
15:10-17:51 **4: Kurobe Dam (Tateyama Kurobe Alpine Route)**
↓ Bus (the highest dam in Japan: 186m)
20:00 Stay at Nagano City

【10th September, 2008】

7:55 Nagano Sta.
↓ Shinkansen ("Asama 510")
9:10 Omiya Sta.
(transfer)
9:42 Omiya Sta.
↓ Shinkansen ("Hayate 11")
11:36 Mizusawa-Esashi Sta.
↓ Bus
13:00-16:30 **5: Construction Site of Isawa Dam**
↓ Bus
18:00 Stay at Ichinoseki City

【11th September, 2008】

8:30-11:30 **6: Natural Dams in Iwai River by the earthquake in the last June**
↓ Bus
13:00-15:00 **7: Ichinoseki Retarding Basin**
↓ Bus
15:48 Ichinoseki Sta.
↓ Shinkansen ("Yamabiko 60"&"Hayate 20")
18:02 Ueno Sta.
(transfer)
18:33 Ueno Sta.
↓ Joban Line
19:31 Hitachi-No-Ushiku Sta.

Reference 11

Synopsis of Master's Thesis

DAM-BREAK FLOOD ANALYSIS IN MID-DOWN STREAM OF HAN RIVER

DAI Minglong*
MEE07175

Supervisor: A.W. JAYAWARDENA**

ABSTRACT

Dam-break flood with high velocity, huge energy, and much higher peak discharge is extremely abnormal and dangerous for the human kind. There have been around 200 notable dam and reservoir failures worldwide in the twentieth century, and caused catastrophic devastation in the valleys downstream both in terms of lives lost and widespread damage to infrastructure and property.

An analysis on dam-break flood in the Mid-down Stream of Han River, China, was performed. Among those big dams in Han River Basin, Danjiangkou Dam and Yahekou Dam may cause disastrous effect if one or both of them break. After assuming failure parameters of these two dams, peak discharges and hydrographs at dam sites are calculated by empirical methods. Then with the help of HEC-RAS hydraulic model and ARC-GIS, main work is focused on how dam-break flood propagates along the river, what is the relationship between peak discharge and distance, and what are the effects in the downstream when one or both dams break.

Keywords: Dam-break Flood, Mid-down Stream of Han River, HEC-RAS, Propagation

INTRODUCTION

The flood-resist system in mid-down stream of Han River is mainly composed of Danjiangkou Reservoir, embankments, Dujiatai Retarding Area, Dongjing River, and other small retarding areas. At present, when water level in Yangtze River is low, if flood-resist facilities in the basin are regulated properly, flood type of “1935” (100 year return period) can be resisted. After the heightening of Danjiangkou Reservoir is finished in 2009, by utilizing the integrated flood-resist system properly, 200 year return period flood can be managed safely.

It does not seem so meaningful to research on normal and natural flood hazard for the mid-down stream of Han River, so risk from an extremely abnormal and huge flood, dam-break flood, with special characteristics of high un-predictability and devastating destructivity, is mainly researched. The main objectives are to research how the dam-break flood wave propagates along the river, and what is the relationship between peak discharge and distance.

After comparing characteristics of different hydraulic softwares and their availability, since the 1-D model of HEC-RAS is free and the author has some experience in it during studying in ICHARM, it is chosen for simulation.

DAM-SITE FLOOD

There are many reservoirs in the Han River basin, but most of them are small scale or middle scale ones, only the two big dams of Danjiangkou dam with a normal storage of 29.05 billion m³, and

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Yahekou dam with a normal storage of 894 million m³ will cause serious effect to downstream if any or both of them fail.

After analyzing the possibility of dam break, the situation of Danjiangkou reservoir and Yahekou reservoir failure by an extremely strong earthquake when their water levels are normal is considered. An illustration of breaking reservoirs, river net and important cities in the study area is shown in Fig.1.

Peak discharges at dam sites are calculated by some empirical formula.

According to the layout plan of Danjiangkou Dam, the most probable failure situation is main dam body partly collapses transversely and instantaneously. After analyzing the longitudinal sectional profile, the remaining body height is assumed as 30m holding a remaining storage of 7.672 billion m³, and water volume escaping from the reservoir is 21.378 billion m³. The remaining concrete dam body acts as a broad crest weir, so the peak discharge of the dam site is calculated by the weir formula

$$Q_m = 1.30 \cdot B \cdot H^{\frac{3}{2}} \quad (1)$$

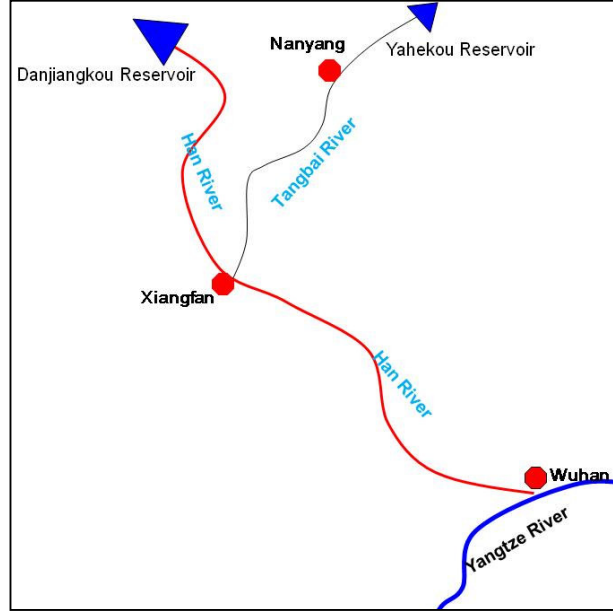


Fig.1 Illustration of Study Area

Where H is water head above the weir, Q_m is peak discharge at the dam site, B is width of breach, and the calculated peak discharge at Danjiangkou Dam site is 127,000m³/s.

For Yahekou Dam, the most dangerous situation is the whole main dam body breaches instantaneously. The calculation of peak discharge is calculated by the formula

$$Q_m = \lambda B \sqrt{g} H_0^{1.5} \quad (2)$$

Where g is acceleration of gravity, H_0 is initial depth, λ is discharge coefficient, and the calculated peak discharge at Yahekou Dam site is 95,600m³/s.

Hydrology Bureau, Yangtze Water Resources Commission used a dimensionless curve to calculate hydrographs at dam sites. Their results were used as input condition for flow routing in downstream.

HYDRAULIC MODEL

The physical laws which govern the flow of water in a stream are: (1) the principle of conservation of mass (continuity), and (2) the principle of conservation of momentum. The most successful and accepted procedure for solving the one-dimensional unsteady flow equations is the four-point implicit scheme, also known as the box scheme, which is shown in Fig.2.

Under this scheme, space derivatives and function values are evaluated at an interior point, $(n + \theta)\Delta t$. Thus values at $(n+1)\Delta t$ enter into all terms in the equations. For a reach of river, there is a system of simultaneous equations. The simultaneous solution is an important aspect of this scheme because it allows information from the entire reach to influence the solution at any one point. Consequently, the time step can be significantly larger than with explicit numerical schemes.

Continuity Equation

The continuity equation describes conservation of mass for the one-dimensional system, and it can be written as:

$$\Delta Q + \frac{\Delta A_f}{\Delta t} \Delta x_f + \frac{\Delta A_c}{\Delta t} \Delta x_c + \frac{\Delta S}{\Delta t} \Delta x_f = \bar{Q}_l \quad (3)$$

Where Q is flow, A is cross-sectional area, S is storage from non conveying portions of cross section, and the subscripts c and f refer to the channel and floodplain respectively, $\bar{Q}_l$ is the average lateral inflow.

Momentum Equation

The momentum equation states that the rate of change in momentum is equal to the external forces acting on the system, and it can be written as:

$$\frac{\Delta(Q_c \Delta x_c + Q_f \Delta x_f)}{\Delta t \Delta x_e} + \frac{\Delta(\beta V Q)}{\Delta x_e} + g \bar{A} \left(\frac{\Delta z}{\Delta x_e} \bar{S}_f \right) = 0 \quad (4)$$

Where: x is distance along the channel, and the subscripts c and f refer to the channel and floodplain respectively, Δx_e is equivalent flow path.

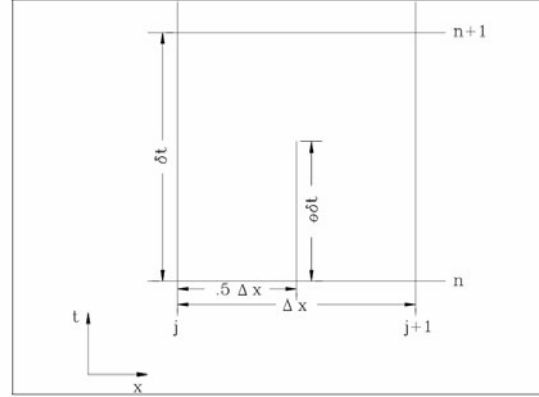


Fig.2 Typical finite difference cell

HYDRAULIC SIMULATION

Geometric data in DEM type is downloaded from HydroSHEDS, with a cell grid of 90×90m. Though this data is still not precise enough, it's the only geometric data available by now.

As shown in Fig.3, between every reach, at the upstream, initial hydrograph is put into the HEC-RAS hydraulic model as input condition, the hydraulic equations of continuity and momentum are solved by HEC-RAS model, and the downstream hydrograph is obtained.

For simplicity and more precise results, the whole study area is divided into two parts, one is Tangbai River, the tributary, and the other is Han River, the main stream. The two rivers join at the point of Xiangfan city.

Simulation process for the whole study area is:

- Suppose only Danjiangkou Dam breaks, simulate dam-break flood from its dam site along the Han River main stream to the river confluence;
- Suppose only Yahekou Dam breaks, simulate dam-break flood from its dam site along

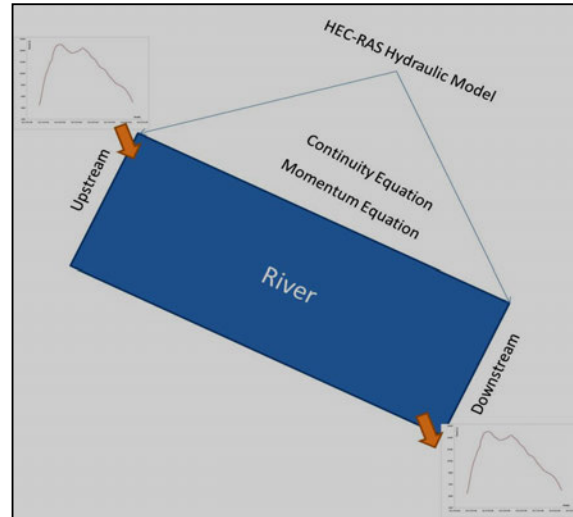


Fig.3 Illustration of Simulation Method

Tangbai River to its river confluence at Xiangfan city, then judge whether there is a need for flow routing further along main stream of Han River or not;

- Suppose both Danjiangkou Dam and Yahekou Dam break, flow routing their dam-break flood individually to the confluence point of Xiangfan, and merge hydrographs of Danjiangkou and Yahekou at Xiangfan together, then judge whether to simulate downward to Han River confluence or not.

For get a stable result, the main stream of Han River and the tributary of Tangbai River are both divided into seven reaches. At the first reach, hydrograph at Dam site is put into the model as upstream boundary condition, calculation is conducted by HEC-RAS model, and hydrograph of down stream is obtained. For next reach, the hydrograph of the previous down stream is treated as new upstream boundary condition, and the hydrograph of the new down stream is obtained. Repeating this process, hydrographs of other downstream reaches can be obtained.

CONCLUSIONS

Hydrographs of the seven downstream reaches along the Han River main stream are shown in Fig.4, and hydrographs of down streams along Tangbai River are shown in Fig.5.

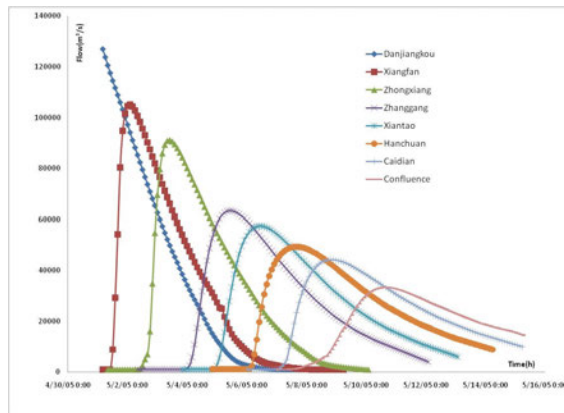


Fig.4 Hydrographs of different points along Han River

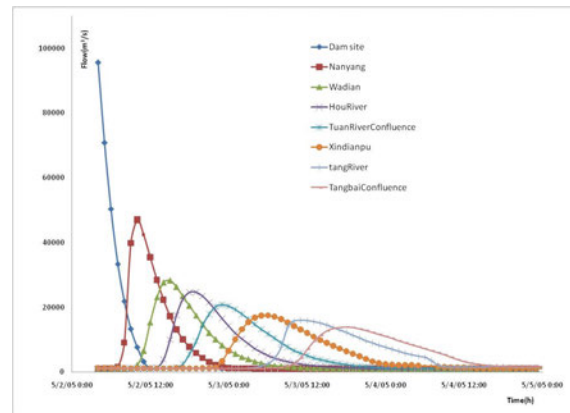


Fig.5 Hydrographs of different points along Tangbai River

The main conclusions of this study are following

- If only Yahekou Dam breaks with normal water level, the effect of Yahekou failure only exists in Tangbai River. It will not affect greatly to main stream of Han River. Peak discharge at Nanyang is $47,000\text{m}^3/\text{s}$, with a return period of 10,000 years. The whole city is terribly inundated, and inundation depth is about 3-4 meters, but in lower parts, the depth will be about 5 meters. But when the dam-break flood wave reaches Tangbai River confluence, peak discharge is $13,900\text{m}^3/\text{s}$, and the return period is only about 2 years.
- If only Danjiangkou Dam breaks with normal water level, the affected area is almost the whole Mid-down Stream of Han River, and it will not cause serious effect to Yangtze River. Peak discharge at Xiangfan is $105,000\text{m}^3/\text{s}$, return period is 10,000 years. Almost whole Xiangfan City is inundated with the water depth of about 3 meters. And in some lower area, the water depth will be 6 meters. Peak discharge at Zhongxiang is $91,000\text{m}^3/\text{s}$, return period is more than 20,000 years. Almost whole Zhongxiang City is inundated with the water depth of about 4 meters. And in some lower area, the water depth will be 6 meters. At last when dam-break flood wave reaches Yangtze River main stream, the peak discharge at Han River confluence is $33,300\text{m}^3/\text{s}$, it will not cause huge disaster for downstream of Yangtze River.

- If both Yahekou and Danjiangkou break at the same time, the total effect to the downstream is somewhat same as that from Danjiangkou only. The two flood waves do not reach Xiangfan at the same time. When flood wave from Danjiangkou Dam propagates to Xiangfan City, the wave from Yahekou Dam has not reached. The aggregated peak discharge is $106,000\text{m}^3/\text{s}$. When the peak discharge in Tangbai River reaches Xiangfan, peak discharge in Han River has already passed, the aggregated discharge is $101,000\text{m}^3/\text{s}$. Even if the two individual peak discharges are added directly, the merged peak discharge is $119,000\text{m}^3/\text{s}$, only is about 10% more than Danjiangkou's.

It will cause huge hardships for rescue efforts and evacuation after strong earthquake. How to evacuate the large population on time under such abnormal condition is a hard challenge for disaster management center.

DISCUSSIONS

- This research is based on dam-break flood from one or both of Danjiangkou Dam and Yahekou Dam failing with normal water level because of strong earthquake. But if these dams fail with higher water level when heavy rain and strong earthquake occur at the same time, the effect in the downstream is more serious than the above conclusions.
- Geometric data used in this research is downloaded from HydroSHEDS, the accuracy is not very high. It is certain it caused deficiency in the results. A more precise result can be obtained with a more accurate DEM data.
- In HEC-RAS, better results can be obtained by more cross sections along the river. But because of some unknown reasons, if the number of cross sections is more than a certain number in ARC-GIS, it exports only blank data without any information. It is certain that the less cross section also affected the result.
- Because of inconvenience of collecting data, and some parameters are assumed in this research, so it may contribute deficiency to the result.

SUGGESTIONS

- In most cases, dam failure could have been prevented if the structure had been properly maintained. So safety management of these two reservoirs is of great importance. New regulations should be made based on existing ones and safety education should be strengthened, any break from man wrong doings should be avoided.
- Because the results are got from 1-D hydraulic model and the geometric data is not precise enough, the results is certain to be relatively rough. To get a more accurate result, further researches applying 2-D or 3-D models with a more precise geometric data should be implemented if possible in the future.
- Warning systems should be strengthened in the study area. In case of dam breaks, timely dissemination of evacuation order on time is of great importance for disaster mitigation. Especially in the situation of breaking from strong earthquake, information should be successfully disseminated even if normal communication system be destroyed.
- Emergency plan should be made. Other researches should be made on how to rescue affected people, and how to evacuate a big population on time before dam-break flood reaches.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my supervisor Professor A.W. Jayawardena and Dr. Rabindra Osti of PWRI for their valuable support, suggestion and guidance during my study.

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DEVELOPMENT OF FLOOD FORECASTING MODEL IN BRAHMAPUTRA VALLEY OF INDIA

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ABSTRACT

In India the Himalayan rivers account for maximum flood damage in the country. The problem of flood in the state of Assam is well known and every year it becomes a recurring problem to the entire region. The flood in Assam is mainly from river Brahmaputra which is the biggest river in the Indian Sub-continent. These flood hazards which claim hundreds of human lives and innumerable numbers of cattle and wildlife every year.

The study on flood forecasting and warning plays a significant role in saving human lives and movable properties by informing the people in advance about the likely level of water and its duration at specific places. It also helps in organizing timely rescue and flood fighting measures in order to prevent or minimize the damage to flood protection works like embankments. Flood forecasting is an important non-structural measure of flood prevention. Hydrologists have done so much work on it and are still in search for better flood forecasting technique. Flood prediction currently relies mostly on statistical techniques and historical records of stream behavior.

The main objective of this study is to develop an advance warning system of incoming flood, so that an early warning can be given to the people likely to be affected. The problem investigated in this dissertation work is the development of a flood forecasting model of river Brahmaputra at Sivasagar. For this a detailed analysis has been carried out with a series of locally available data sets. The daily stage data of main river Brahmaputra and its upstream tributaries along with the daily rainfall data of that region have been chosen for use in this dissertation work.

In this study, a discrete, linear time series model has been developed to forecast the flood of river Brahmaputra at Sivasagar for real time flood forecasting. This model can be used as a forecaster at Sivasagar which will help to give early warning to the local community and to the people concerned.

Key words: Discrete time series flood forecasting model

INTRODUCTION

Flood is one of the most damaging natural disasters in this planet that affect many countries in the world year after year. The impact of flooding ranges from the destruction of property, loss of agricultural production and disruption of transport and services to loss of lives. Flood is a natural disaster that results from severe combination of critical meteorological and hydrological conditions which may be gripped by man made causes. To minimize the effects of flooding there are two complementary approaches: (i) flood protection works, including the design and construction of river banks, dams and flood storage areas to protect flood prone areas, and (ii) flood warning. Effective

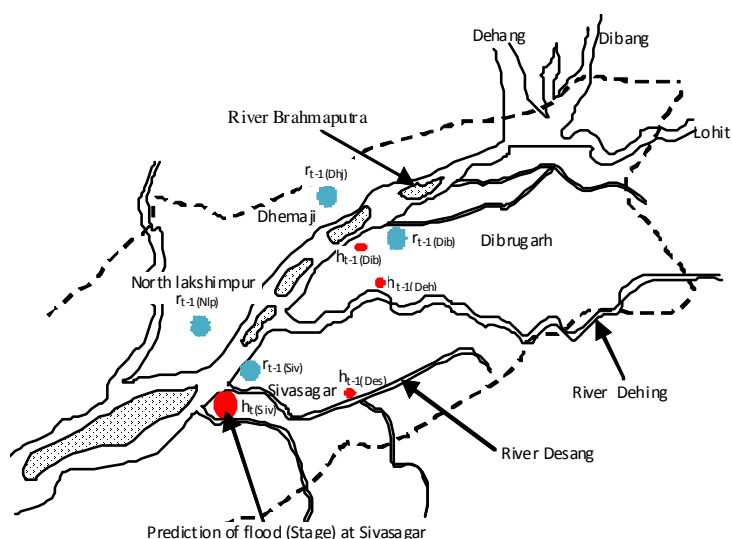
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flood warning can facilitate evacuation of people, property and livestock, amelioration through temporary flood proofing, early alerting of emergency services and control by adjusting reservoir discharges or preparation of retarding ponds. Flooding cannot be completely avoided, but damages from severe flooding can be reduced if effective flood prevention scheme is implemented. This can be achieved if sufficient information for flood forecasting is acquired both in time and in quality.

DATA

This flood forecasting model has been run with the stage data of river Brahmaputra and its upstream tributaries along with the respective rainfall data of the area. Fig.1 shows the various stage gauge stations and rain gauge stations along with its river system. The river under study is Brahmaputra and the flood forecasting model has been prepared to forecast flood at Sivasagar. There are two main tributaries of river Brahmaputra upstream of Sivasagar as shown in the figure namely Dehing and Desang. Data have collected from four Divisions such as Sivasagar, Dibrugarh, North Lakshimpur and Dhemaji. Sivasagar & Dibrugarh Divisions are in the south bank of river Brahmaputra and North Lakshimpur & Dhemaji in the north bank of river Brahmaputra.



These four Divisions have their own daily rain gauge station. These Divisions also collect daily stages of respective rivers during official flood season i.e. from 15th May to 15th Oct. Therefore, four sets of stage data and four sets of rainfall data are used in this study. Out of which two stages of Brahmaputra itself and two from its upstream tributaries are taken into consideration. The period of data used for this study is from 1993 to 2004 i.e. for twelve years daily data during flood period.

Fig.1 Basin Map

THEORY AND METHODOLOGY

Historic data such as stage or discharge of a river and or rainfall data of that area are required in general for flood forecasting purposes. Tributaries stage or discharge data are also considered for flood forecasting in a multi tributary river system. Different flood forecasting models are formulated depending upon the availability of hydrological and hydro-meteorological data, the basin characteristics, warning time required and the purpose of forecast.

The Brahmaputra is a big river with large numbers of tributaries in India. In this study a linear time series model has been developed for flood forecasting of river Brahmaputra at Sivasagar, Assam. This model is based on the various upstream gauges data of river Brahmaputra and its tributaries along with respective rainfalls of the area. Stage of Brahmaputra, at Sivasagar is influenced by the stage of upstream gauge station of Brahmaputra at Dibrugarh and the stages of its two upstream tributaries namely Dehing and Desang. Stage or discharge of a river is also directly related to the rainfall of the basin of that river. Stage of Brahmaputra at Sivasagar is also dependant on rainfall of the upstream areas and therefore rainfall data of the surrounding areas of Sivasagar are also taken into account.

Model building process

A linear time series model has been developed for flood forecast of river Brahmaputra at Sivasagar. This model is based on the various upstream gauge data of river Brahmaputra and its tributaries along with respective rainfalls of the area. The daily gauge reading and daily respective rainfall readings of (t-1) time are used as input in the model to predict the stage of 't' time. The stage at Sivasagar in 't' time depends on the stages at Sivasagar, Dibrugarh, Dehing at Joangaon, Desang at Nangalamora in (t-1) time and rainfall at Sivasagar, North Lakshimpur, Dibrugarh & Dhemaji in (t-1) time respectively that is stage at Sivasagar in 't' time is the function of stages and rainfall of upstream stations in (t-1) time. The model in general is expressed as:

$$h_t = f(h_{t-1}, h_{t-1(Dib)}, h_{t-1(Deh)}, h_{t-1(Des)}, r_{t-1(Siv)}, r_{t-1(Nlp)}, r_{(t-1)Dib}, r_{(t-1)Dhg})$$

$$h_t^{Pred} = a_1 h_{t-1} + b_1 h_{t-1(Dib)} + c_1 h_{t-1(Deh)} + d_1 h_{t-1(Des)} + e_1 r_{t-1(Siv)} + f_1 r_{t-1(Nlp)} + g_1 r_{(t-1)Dib} + i_1 r_{(t-1)Dhg}$$

where, h_t – Stage of Brahmaputra at Sivasagar in 't' – time
 h_{t-1} – Stage of Brahmaputra at Sivasagar in (t – 1)time
 $h_{t-1(Dib)}$ – Stage of Brahmaputra at Dibrugar in (t – 1)time
 $h_{t-1(Deh)}$ – Stage of Dehing at Jungaon in (t – 1)time
 $h_{t-1(Des)}$ – Stage of Desang at Nangalamora in (t – 1)time
 $r_{t-1(Siv)}$ – Rainfall of Sivasagar in (t – 1)time
 $r_{t-1(Nlp)}$ – Rainfall of North Lakshimpur in (t – 1)time
 $r_{t-1(Dib)}$ – Rainfall of Dibrugar in (t – 1)time
 $r_{t-1(Siv)}$ – Rainfall of Dhemaji in (t – 1)time
 h_t^{Pred} – Stage of Brahmaputra at Sivasagar in 't' – time
 $a_1, b_1, c_1, d_1, e_1, f_1, g_1, i_1$ are the parameters which are to be found-out.

The parameters $a_1, b_1, c_1, d_1, e_1, f_1, g_1, i_1$ are calculated by the method of least squares. The least squares method defines "best" as when the sum, S , of squared residuals is a minimum. In this method of calculations 'S' is considered as the sum of squares of the errors up to n^{th} stages and mathematically it can be expressed as follows:

$$S = e_1^2 + e_2^2 + \dots + e_n^2$$

$$= \sum_{i=1}^n e_i^2$$

$$s = \sum_{i=1}^n (h_t^{Pred} - h_t^{Obs})^2$$

$$= \sum_{i=1}^n (a_1 h_{t-1} + b_1 h_{t-1(Dib)} + c_1 h_{t-1(Deh)} + d_1 h_{t-1(Des)} + e_1 r_{t-1(Siv)} + f_1 r_{t-1(Nlp)} + g_1 r_{(t-1)Dib} + i_1 r_{(t-1)Dhg} - h_t^{Obs})^2$$

'S' is minimized when its gradient with respect to each parameter is equal to zero. The elements of the gradient vector are the partial derivatives of S with respect to the parameters. On the other hand we can

assume that 'S' gets zero so that the least square error has a minimum. If we get the first derivative of 'S', the equation will be as follows:

$$\begin{aligned} \frac{\partial S}{\partial a_1} = 0 = & \sum_1^n 2 \cdot (a_1 h_{t-1} + b_1 h_{t-1(Dib)} + c_1 h_{t-1(Deh)} + d_1 h_{t-1(Des)} + e_1 r_{t-1(Siv)} \\ & + f_1 r_{t-1(Nlp)} + g_1 r_{t-1(Dib)} + i_1 r_{t-1(Dhg)} - h_t^{Obs}). h_{t-1} \\ \therefore a_1 \sum_1^n h_{t-1}^2 + b_1 \sum_1^n h_{t-1(Dib)} h_{t-1} + c_1 \sum_1^n h_{t-1(Deh)} h_{t-1} + d_1 \sum_1^n h_{t-1(Des)} h_{t-1} \\ & + e_1 \sum_1^n r_{t-1(Siv)} h_{t-1} + f_1 \sum_1^n r_{t-1(Nlp)} h_{t-1} + g_1 \sum_1^n r_{t-1(Dib)} h_{t-1} \\ & + i_1 \sum_1^n r_{t-1(Dhg)} h_{t-1} = \sum_1^n h_t^{Obs} h_{t-1} \end{aligned} \quad (1)$$

Similarly, differentiating 'S' with respect to $b_1, c_1, d_1, e_1, f_1, g_1, i_1$ other 7 equations can be obtained and the co-efficient of the equations can be arranged in the following matrix form to calculate the parameters $a_1, b_1, c_1, d_1, e_1, f_1, g_1$ & i_1 of the model.

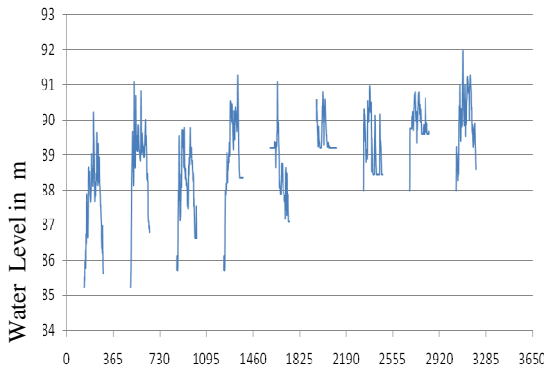
$$\begin{bmatrix} \sum h_{t-1} h_{t-1} & \sum h_{t-1} h_{t-1(Dib)} & \dots & \sum h_{t-1} r_{t-1(Dhg)} \\ \sum h_{t-1(Dib)} h_{t-1} & \sum h_{t-1(Dib)} h_{t-1(Dib)} & \dots & \sum h_{t-1(Dib)} r_{t-1(Dhg)} \\ \vdots & \vdots & \ddots & \vdots \\ \sum r_{t-1(Dhg)} h_{t-1} & \sum r_{t-1(Dhg)} h_{t-1} & \dots & \sum r_{t-1(Dhg)} r_{t-1(Dhg)} \end{bmatrix} \begin{bmatrix} a_1 \\ b_1 \\ \vdots \\ i_1 \end{bmatrix} = \begin{bmatrix} \sum h_t^{Obs} h_{t-1} \\ \sum h_t^{Obs} h_{t-1(Dib)} \\ \vdots \\ \sum h_t^{Obs} r_{t-1(Dhg)} \end{bmatrix}$$

RESULTS AND DISCUSSION

First trial

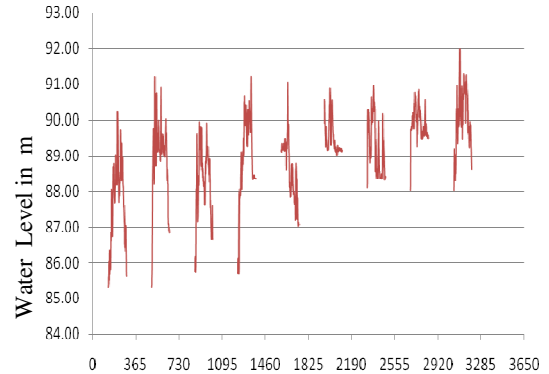
In this trial, out of 12 years data, 9 years data from 1993 to 2001 have been used to calculate the parameters and 3 years data from 2002 to 2004 have been used for prediction purposes. Following values of the parameters and graphs have been obtained in this trial:

$$\begin{aligned} a_1 &= 9.78\text{E-}01, & b_1 &= 8.47\text{E-}02, & c_1 &= -7.96\text{E-}02, & d_1 &= 9.32\text{E-}03, \\ e_1 &= 4.03\text{E-}05, & f_1 &= 1.38\text{E-}03, & g_1 &= 6.49\text{E-}04, & i_1 &= 8.01\text{E-}04 \end{aligned}$$



Nos. of Days (154 Days/Year) (1993-2001)

Fig. 2 Observed stages in calibration period



Nos. of Days (154 Days/Year) (1993-2001)

Fig. 3 Predicted stages in calibration period

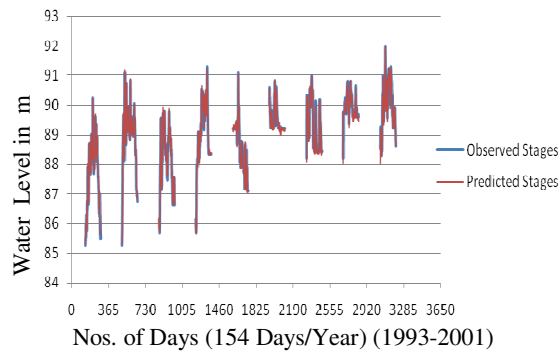


Fig. 4 Observed & Predicted stages in calibration period

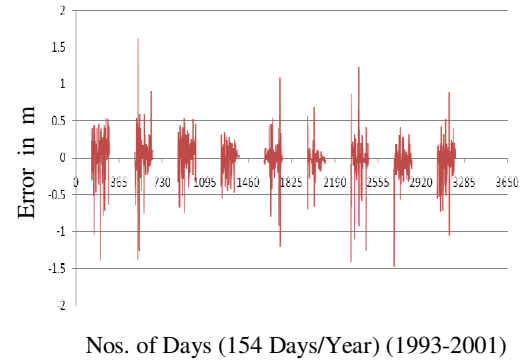


Fig 5 Prediction errors in calibration period

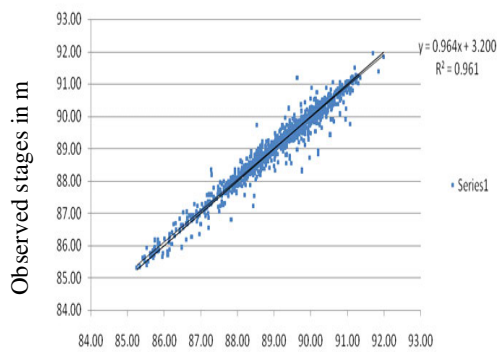


Fig. 6 Observed Vs Predicted Stages

Above results are obtained from the 9 years data set from 1993 to 2001. The value of ' R^2 ' i.e. coefficient of determination has been calculated as 0.961 as shown in Fig 6 and root mean square error (RMSE) has been calculated as 0.23.

The values of parameters when used to predict the flood for the period of 3 years from 2001 to 2004 then the value of coefficient of determination (R^2) decreases to 0.920 and RMSE increased up to 0.30 which are not so significant.

In the same way second, third and fourth trial have been done. Second trial has been run with average data. Data are not continuous in the first trial and for which calculations are interrupted. Therefore, to eliminate this problem, average data are prepared by simply taking the average of each days stage and rainfall of the calibration period i.e. 1993 to 2001.

In the third trial, the daily gauge reading and daily respective rainfall readings of (t-1) & (t-2) time are used as input into the model to predict the stage of 't' time. The stage at Sivasagar in 't' time is calculated based on the stages at Sivasagar at (t-1) time and Dibrugarh, Dehing, Desang in (t-2) time, similarly rainfall also at Sivasagar & North Lakshimpur at (t-1) time and Dibrugarh & Dhemaji in (t-2) time respectively. This is considered because of the lead time difference. Since lead time of Dibrugarh, Joangaon, Nangalamora, Dhemaji, North Lakshimpur and Sivasagar are not the same. Therefore, t, (t-1) & (t-2) time have been considered and the difference between each time is 24 hours.

Table 1 Comparison of different parameters

Trials	a_1	b_1	c_1	d_1	e_1	f_1	g_1	i_1	k_1
1	9.78E-01	8.47E-02	-7.96E-02	9.32E-03	4.03E-05	1.38E-03	6.49E-04	8.01E-04	-
2	7.91E-01	1.95E-01	-5.11E-02	3.04E-02	1.37E-04	4.12E-03	1.45E-03	4.65E-04	-
3	9.17E-01	4.90E-01	-4.80E-01	3.31E-02	2.73E-03	1.29E-03	2.05E-03	5.55E-04	-
4	9.76E-01	7.96E-02	-5.05E-02	-1.39E-02	1.93E-04	1.52E-03	6.52E-04	8.08E-04	2.71E-06

Table 2 Comparison of different ' R^2 ' & 'RMSE'

Trials	Calibration period (1993-2001)		Verification period (2002-2004)	
	R^2 Value	RMSE	R^2 Value	RMSE
1	0.961	0.23	0.920	0.30
2	0.982	0.07	0.916	0.34
3	0.887	0.39	0.827	0.48
4	0.961	0.23	0.918	0.30

In the fourth trial (t-1) periods data are considered to predict stage at 't' time, but here one constant term is also taken into consideration which is independent of stage and rainfall.

Various results of these four trial have shown in Table 1 and Table 2 for comparison.

CONCLUSIONS

Among the four trials first and fourth trial have very less differences. The R^2 value is high in the first trial and at the same time RMSE is also low compared to the other trials. Therefore, first trial model will be the suitable model among the four trials for flood prediction of river Brahmaputra at Sivasagar.

Secondly, this is not a physically based model and that is why it can not minimize error to zero. But stochastic type of model can bring the error within an acceptable limit. Since, this model is also stochastic in nature it cannot eliminate error completely and it try to minimize error within an acceptable limit.

RECOMMENDATION

Advanced forecasting techniques are required to be studied and should be used on operational basis for real time flood forecasting if suited well. On the other hand, the network of rain gauges, especially in the mountain region is not adequate as per the WMO suggested norm. The water levels are also measured using conventional methods. Automatic rain gauge network has to set up and recorded for the entire basin with international co-operation.

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FLOOD HAZARD MAPPING OF DHAKA-NARAYANGANJ-DEMRA (DND) PROJECT USING GEO-INFORMATICS TOOLS

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ABSTRACT

Dhaka-Narayanganj-Demra (DND) Project is one of about 700 water sector projects built by Bangladesh Water Development Board (BWDB) in Bangladesh. It was a successful project from all considerations. But during 1998 flood, there was overtopping and breaching of embankment. At that time BWDB was able to stop much inundation by doing emergency work. Still many people are building their houses and factories in low-lying area. The study area is nearer to central Dhaka city. So urbanization is increasing rapidly. Again, due to global warming, intensity and magnitude of different disasters are increasing. That is why this project is chosen as study area to examine the inundation depth in overtopping occurrence and that result is used to prepare an informative Flood Hazard Map.

A flood hazard map of DND Project was developed using the 1988 flood data. The inundation simulation was conducted using ArcGIS and HEC-RAS considering water level of 6.93 m at Shitalakhya river and that of 7.23 m at Buriganga river. The analysis shows that about 21 % of the total study area has been inundated by less than 1 m depth which is 45 % of the total inundated area. 15 % of the total study area has been inundated by 1 m to less than 2 m depth which is 32 % of the total inundated area. So in total 36 % of the total study area has been inundated by less than 2 m depth which is 77 % of the total inundated area. The maximum inundation depth has been found 6.67 m. This affected about 47 % of land of the study area and about 250,000 people. But the residents are not aware of it. The results obtained in this study would provide essential information for flood plain management aimed at containing flood damages in future. The way of dissemination of FHM has been done to raise public awareness.

Keywords: Flood Hazard Map, Inundation Simulation, DND

INTRODUCTION

Bangladesh is one of the most disaster prone countries in the world. It is a low-lying deltaic country, which is situated in South Asia, is formed by the Ganges, the Brahmaputra and the Meghna rivers. The study area is Dhaka-Narayanganj-Demra (DND) Project. The area is about 56.79 sq. km and about 800,000 people are living here. During 1998 flood, there was overtopping and breaching of embankment. At that time BWDB was able to stop much inundation by doing emergency work. Still many people are building their houses and factories in low lying area. The housing companies have acquired cheap land in flood plains and developed residential colonies there, which are very vulnerable to flooding. Due to global warming, intensity and magnitude of different disasters are increasing. Hence, there is a need to have a decision support system for the planners and developers.

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The important reasons of selecting the area are: 1.The area is very important as it is very near to the central Dhaka city; 2.Urbanization is progressing rapidly in this area with the increasing population; 3. Vulnerability of the residents is also increasing rapidly; and 4. Availability of Data.

The goal of this thesis is to examine the inundation depth when overtopping occurs and to prepare an informative Flood Hazard Map and the way to disseminate the information to increase awareness of residence.

Geographic Information System (GIS) provides state of the art methods for the analysis and presentation of spatial and temporal data and information which are easily visualized by the administrators and planners. The flow and transport phenomena of the river can be easily modeled using hydrodynamic models.



Fig. 1 Location of Study area with respect to Greater Dhaka city

DATA

In this analysis two types of data have been used. They are Hydrological data and Topographic data. Hydrological data includes discharge and water levels of Shitalakhya and Buriganga River. Topographic data includes Digital Elevation Model (DEM), Satellite image and Land use map of the study area. The used stage hydrograph of 1998 flood have been shown in Fig. 2 and 3.

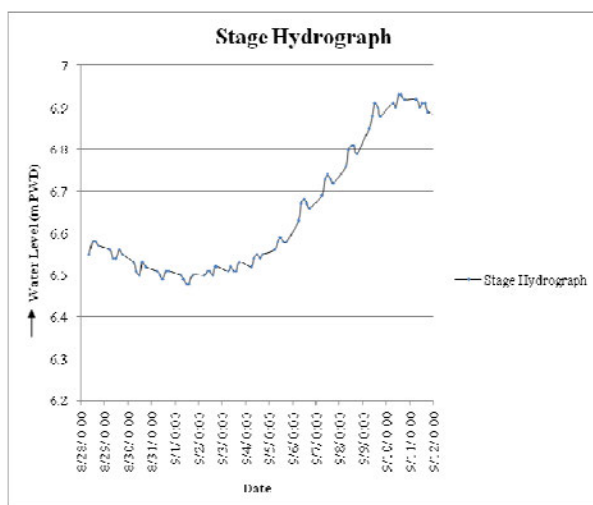


Fig. 2 Stage hydrograph at Demra of Shitalakhya river during 1998 flood

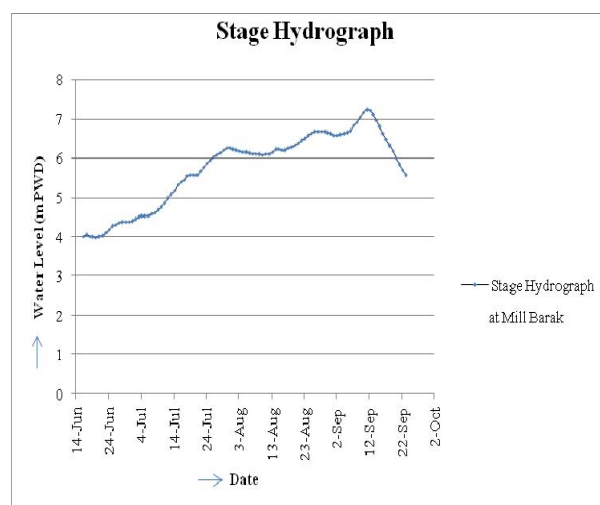


Fig. 3 Stage hydrograph at Mill Barak of Buriganga river during 1998 flood

METHODOLOGY

Geo-informatics provides various tools for the analysis and visualization of spatial and temporal data. In this study, ArcGIS 9.1 (ESRI, 1999) and HEC-RAS 3.1.3 (Hydrologic Engineering Center, 2002) have been used. HEC-RAS have been used in this study to acquire cross-sections from DEM, to

interpolate flood water levels between sections, to compute flood depth from DEM and the preparation of hazard maps.

HEC-RAS is one-dimensional hydrodynamic model capable of performing water surface profile calculation for steady and unsteady flow in natural or constructed channels. The water surface profiles for unsteady flow are computed by solving the continuity and momentum equations which are expressed mathematically in the form of partial differential equations. Within HEC-RAS, these equations are solved using four-point implicit finite difference scheme also known as box scheme. In this study, HEC-RAS is used to compute unsteady and steady flow water level along the channel reach for 1998 flood, which is required to prepare a flood hazard map.

The methodology as shown in flow chart of Fig. 4 can be summarized as following steps: 1. Preparation of Digital Elevation Model (DEM); 2. Delineation of watershed and drainage network; 3. Applying of Boundary conditions and cross-section data; 4. Estimation of spatial and temporal variation of stream flows for different flood events using hydrodynamic model (HEC-RAS); 5. Preparation of flood hazard map for severe flood events using GIS; and 6. Find out the way to disseminate flood hazard map to increase awareness.

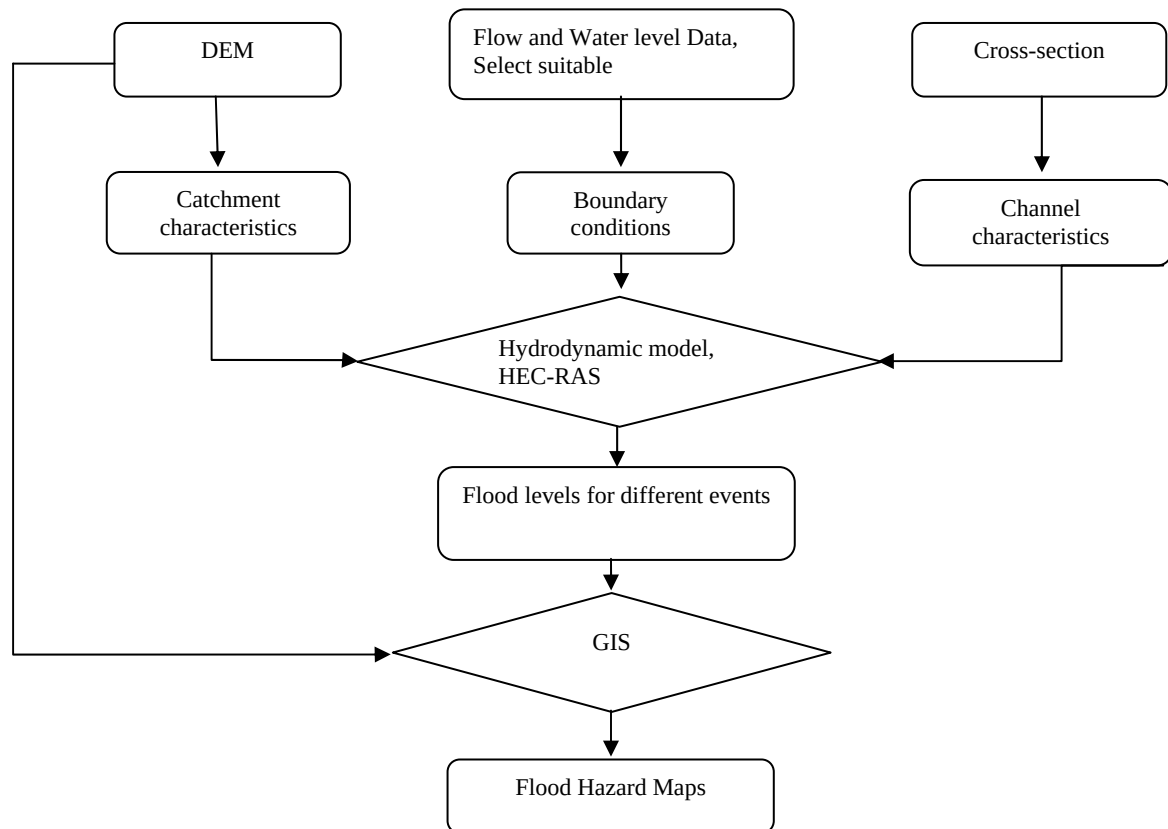


Fig. 4 Flow chart of Methodology

DEM data file for this study has been collected from the HydroSHEDS (Hydrological data and maps based on Shuttle Elevation Derivatives at multiple Scales). For this study, DEM of the study area has been extracted from these DEM data which is shown in Fig. 5. And the data have been checked with some actual ground elevation data near the study area.

Satellite image was collected from Google Earth which is not Geo-referenced. So the image has been Geo-referenced according to the geographic co-ordinate system. DEM is also in geographical coordinate system: GCS_WGS_1984. Then the DEM and Geo-referenced image have been projected into coordinate System: WGS_1984_UTM_Zone_45N from the geographical coordinate system.

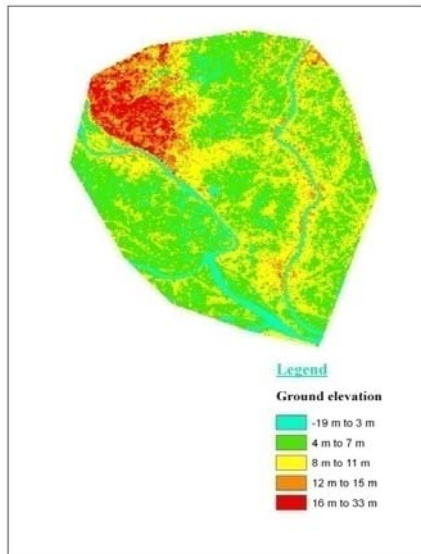


Fig. 5 Extracted DEM of the study area

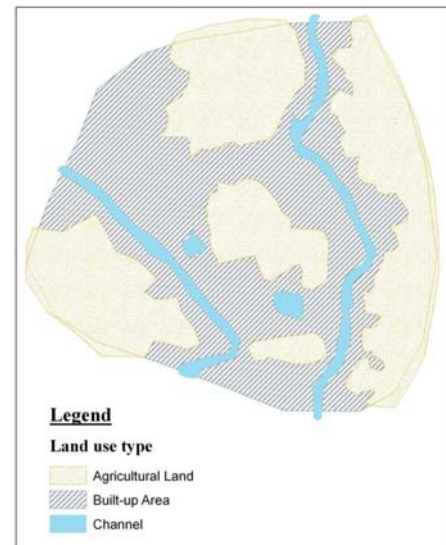


Fig. 6 Created Land Use map of the study

It is observed that for analysis of large area, downloaded land use map can be used. In case of small area we need detailed land use map. So a detailed land use map has been created with the help of ArcGIS. Created land use map is shown in Fig. 6.

Different Manning's n value has been assigned for different land use type which is shown in Table 1 (Chow, V. T., Maidment, D. R., and Mays, L. W. 1988).

Table 1 Assigned Manning's n Value for Different Land Use Type

Land Use Type	Manning's n Value
Built-up Area	0.08
Channel	0.04
Agricultural Land	0.035

SIMULATION RESULTS AND OBSERVATIONS

The simulation has been done for three cases. Firstly unsteady flow analysis has been done with discharge data of 1988 and 2005 flood events. Secondly steady flow analysis has been done with water level data of 1998 flood event. Finally unsteady flow analysis has been done with water level data of 1998 flood event. Second and third analyses give same result which has been used for flood hazard map.

The analysis shows that about 47 % of the total study area has been inundated. 21 % of the total study area has been inundated with less than 1 m depth which corresponds to 45 % of the total inundated area. 15 % of the total study area has been inundated with 1 m to less than 2 m depth which accounts for 32 % of the total inundated area. So in total 36 % of the total study area has been inundated with less than 2 m depth which accounts for 77 % of the total inundated area. The maximum inundation depth has been found 6.67 m. The detailed result is shown in Table 2.

Table 2 Result of Steady and unsteady flow analysis with water level data

Level of inundation depth	Inundated area (km ²)	Inundated area (% of total inundated area)	Inundated area (% of total study area)
Less than 1 m	12.75	45	21.19
1 m to less than 2 m	9.03	32	15.01
2 m to less than 3 m	4.50	16	7.48
3 m to less than 4 m	1.29	5	2.15
4 m to 6.67 m	0.82	3	1.36

The inundation depth obtained in all simulations at different location has been found reliable because it matches with the field condition. The study area is surrounded by two rivers –Shitalakhya and Buriganga. During flood time the water level in the both rivers are almost the same. For that reason, simulation with one of these rivers or both rivers gives same inundation depth. It is observed that at the boundary of two rivers inundation was all most same.

It is observed that inundation depth is almost same for all simulations. But inundation depth is little more for 1998 flood event. So the results obtained in case of steady and unsteady flow analyses with water level data of 1998 flood event have been used for flood hazard map.

FLOOD HAZARD MAPPING

Flood hazard map have been prepared on the basis of inundation map for unsteady flow analysis with water level data of 1998 flood event. This flood hazard map has been prepared following the Flood Hazard Mapping Manual. This manual was prepared by Flood Control Division, River Bureau, Ministry of Land, Infrastructure and Transport (MLIT), Japan. To prepare a good flood hazard map, town watching and discussion with residents are essential. But that can not be done because study area is far away from here. So location of flood evacuation centers, disaster prevention organizations, flood fighting depots, flood warning speakers and sirens could not be set exactly in the flood hazard map. The final hazard map is shown in Fig. 7.

After preparation of Flood Hazard Map, it is difficult to make it useful. That is why dissemination of flood hazard map is an important task especially in developing countries like Bangladesh. If the distribution can be done properly, it will be helpful to increase awareness. Dissemination should be promoted within all divisions of municipality.

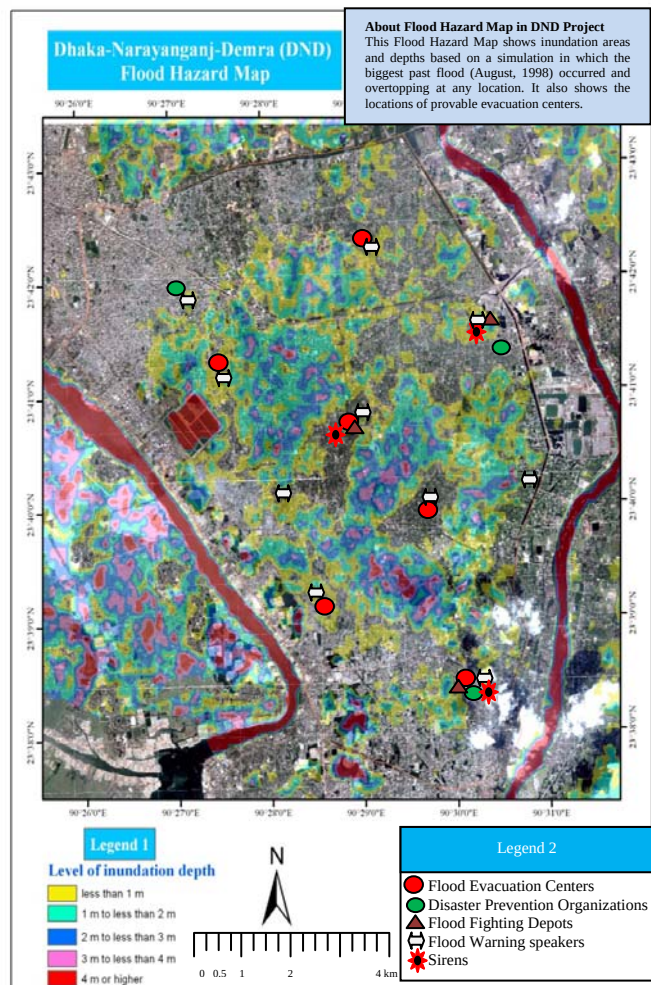


Fig. 7 Dhaka-Narayanganj-Demra Flood Hazard Map

CONCLUSION

Total inundated area is about 28 km² which is about 47 % of total study area and the affected people are about 250,000. Inundation depth ranges from 1 to 3 meter is about 87 % of total inundated area. The north-western part and area nearer to embankment are mostly unaffected. The area which is a little bit away from embankment is mostly vulnerable because many people constructed their houses at lower elevation. The central part has high inundation depth.

RECOMMENDATIONS

The major focus of this study was to assess the vulnerability of the people in this area regarding high flood in Bangladesh. From the results of this study, it appears that if breaching of embankment or high flood occurs, serious damage will be occurred. So, necessary steps should be taken by the government to improve this condition.

Major recommendations for improvement of the project are summarized below:

1. The software HEC-RAS has been used for hydrologic simulation. It allows performing one-dimensional steady flow and unsteady flow calculations. Two-dimensional modeling software can be used for future studies to compare results obtained here.
2. A more detailed Flood Hazard Map can be prepared by conducting town watching and interview with residents and local leaders in the future.
3. For simulation, only river flow is considered. Rainfall, evaporation, percolation can be included for further studies to get better result.
4. After preparing a detailed Flood Hazard Map, it should be distributed to the people in some meeting with the residents. It will be helpful to increase awareness about the flood.
5. During the preparation of Flood hazard map, participation of residents and local leaders is essential to make it useful and to increase awareness and responsibility.

ACKNOWLEDGEMENT

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RAINFALL RUNOFF MODELLING AND INUNDATION ANALYSIS OF BAGMATI RIVER AT TERAJ REGION OF NEPAL

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ABSTRACT

Climatic variability, unplanned land use pattern and encroachment into the flood plain are affecting the hydrology of Bagmati river basin of Nepal. In this study, methodology to improve present flood management system with non-structural countermeasures has been elaborated. Study of hydrological condition, basin scale rainfall runoff modeling and inundation analysis is helpful to prepare community level flood risk management techniques. In order to develop the relationship between rainfall and runoff and hence to develop flood forecasting model, simple statistical tools for hydrological analysis and least square methods of best fit technique is applied within the available historical rainfall and stage data (1980-2004). Flood frequency analysis is performed and floods of different return periods are identified. To minimize the risk from flood, different level inundation of the predicted flood should be known at community level. Hence inundation analysis is performed based on available digital data, satellite imageries, and GIS based numerical models (Arc GIS, its extension HEC-GeoRAS and HEC-RAS software) together with some field observation data. Real time flood forecasting model and inundation depth identifying technique for lower Bagmati watershed are the main outcomes of this study. Results of this analysis are understandable even to the community level people and such approach can be applied to other river basins as well for non structural countermeasure of flood disaster mitigation.

Keywords: Rainfall-runoff modelling, Inundation analysis, Community, Disaster mitigation

INTRODUCTION

Global nature of changes in climate and land use pattern is affecting the hydrology of every river system. Consequences of such effect can be observed as a magnified risk of flood hazard in the downstream reach of Bagmati river basin. In order to minimize the risk from flood hazard, both structural and non-structural mitigation measures have been taken as countermeasures. Rather than relying completely on large structural measures, which may not be sustainable due to economic condition of the country, policies and guidelines need to be developed and implemented as non-structural countermeasures against flood hazard at the community level. Non-structural measures mainly include conservation of watershed, flood plain management, flood forecasting, warning and evacuation system. Hence it is essential to develop methodology to improve present flood management system with non-structural countermeasures. Such non structural countermeasure of flood risk reduction is possible with rainfall runoff modeling and inundation analysis. The main objective of study is to develop the simple rainfall runoff flood forecasting model and inundation depth analysis technique for community level people as a community approach of flood disaster management. As a case study, rainfall-runoff modeling and inundation analysis is elaborated for Bagmati river at Terai region (Plain area in the downstream reach) of Nepal.

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STUDY AREA AND PROBLEM DESCRIPTION

Bagmati river basin lies in central region of Nepal and it covers an area of about 3741 sq. km (Fig.1). It originates in the mountains at about 16 km north-east of Kathmandu and drains out of Nepal across the Indian State of Bihar to reach the Ganges. Its total length is 597 km of which 206.8 km lies in Nepal (DWIDP, 2005). The watershed area draining upto the Pandhare Dovan is 2772 sq.km is called upper watershed area which is the mountainous area whereas below it is called lower watershed area and it's the plain (Terai) area. Every year in monsoon season, high flood at Bagmati river is causing loss of lives and property in the downstream reach of the basin. Due to increasing trend of extreme events and present economic condition of the country, government will not be able to afford huge investment for structural interventions for the entire watershed. So, combination of structural as well as community approach of non-structural flood disaster management would be most economical and effective approach of flood disaster mitigation to save the life and property in the Terai region of Bagmati river basin.

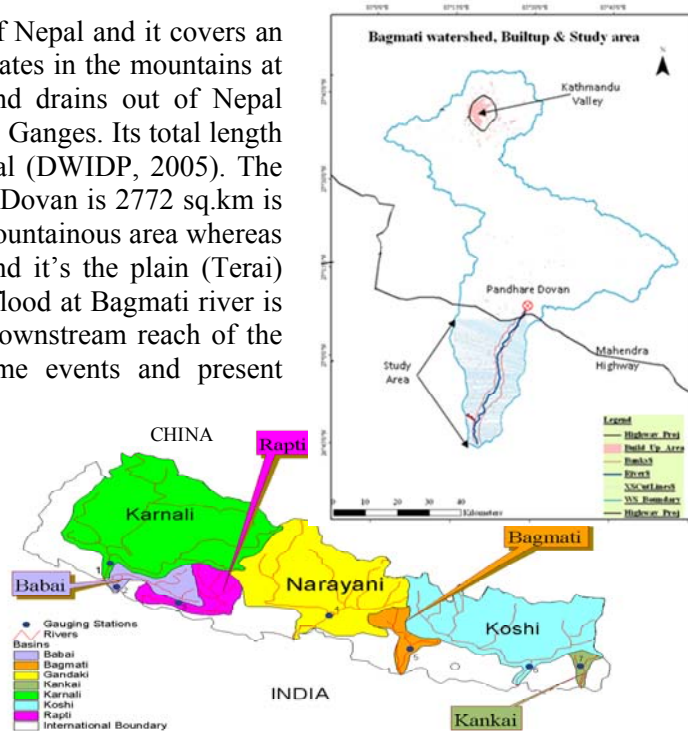


Fig.1 Map of Nepal and study area

DATA

In this study, hydrological analysis is performed using precipitation data (1980-2004) of eleven rain gauge stations within the periphery of the basin. Flood frequency analysis is carried out with instantaneous maximum discharge (1965-2006) measured at Pandhare Dovan. For rainfall runoff modeling, observed stage and flow data (1980-2004) at Pandhare Dovan are used. Inundation analysis is performed utilizing the Digital Elevation Model downloaded from HydroSHEDS. Topographic maps (1:25000), land use map and past historical inundation depths of the study area which were collected from DWIDP, Nepal. Image of the study area is produced from digital data of ALOS, JAXA.

THEORY AND METHODOLOGY

Hydrological modeling of Bagmati river basin

Hydrological modelling of river basin is essential for rainfall runoff modelling and inundation analysis. The rainfall pattern of the region was analyzed with the 25 years (1980- 2004) of available rainfall data. In order to calculate the mean rainfall over an area, Thiessen polygon method is used. This method is considered superior to the arithmetic mean. But this method does not consider the topographical effect (Jayawardena, 2007). In order to simplify the flood forecasting techniques to the community level people, rainfall over an area is correlated with one precise Kathmandu airport station. Using this correlation average rainfall over the region could be calculated if the rainfall of Kathmandu station is known. To establish the relation between flood magnitude and corresponding inundation depth, flood of different recurrent interval are calculated with normal and Gumbel distribution. The primary objective of the flood frequency analysis is to relate the magnitudes of the extreme events to their frequency of occurrence through the use of probability distribution (Chow et al., 1988).

Basin scale flood forecasting modelling

The real time flood forecasting is one of the most effective non- structural measures for flood management. Rainfall covering the river basin and stages at the forecasting station data form the basis for flood forecasting. Out of various techniques available, statistical approach of modeling is chosen for this study. Statistical approach and least square methods of error minimization technique were used to set up the appropriate model within the available data sets. Stages and average rainfall over an area were first of all fitted for the calibration of the model. For calibration, data of 1980 to 1998 are used. After calibration and finding the model coefficients, it's validated using the data from 1999 to 2004. Out of many models set up and tested, modelling using stage and rainfall gave the better result than other setup like rainfall-discharges, only rainfall etc.

Flood characteristics and Inundation analysis

Study of flood characteristics and inundation analysis are essential for non-structural measures of flood management. It is one of the techniques to identify the areas under the risk of flood damage. In this study, inundation analysis is performed using GIS-based numerical models (Arc GIS, its extension HEC-GeoRAS and one dimensional modelling software HEC-RAS). Result of such analysis gives the depth of inundation for flood of different recurrent interval. The most devastating flood in the Bagmati river was in year 1993. So inundation depth simulation was performed for 1993 flood condition and results are compared with the actual inundation depths. To develop a graph which shows the relationship between flood magnitude and inundation depth, simulation with different return period floods were performed. Using such graph, even the community level people can easily find the depth of inundation for different flood magnitude. As the government has planned to protect the whole area by constructing levee, inundation simulation was further elaborated for future full levee protected and levee breach conditions.

RESULTS AND DISCUSSION

Rainfall analysis

Rainfall analysis shows that more than 80% of the rain falls in the monsoon period (June-Sept.) and trend of rainfall is significantly ($\alpha=0.05$) increasing at 95% level of confidence.

Rainfall correlation

Daily average rainfall of Kathmandu airport (st.no.1030) and eleven stations mean rainfall over an area are correlated (Fig. 2). This correlation establishes the relation of rainfall between them.

$$R_{t-1}(\text{average over region}) = 1.3 R_{t-1}(\text{Kathmandu_St}) + 0.327$$

Using this correlation, average rainfall over the region could be calculated if the rainfall of Kathmandu station is known. This correlation would be easier even for the people at community level to find the rainfall over the region for flood forecasting.

Flood frequency analysis

Available 42 years (1965-2004) instantaneous maximum flood events probability distribution shows the Gumble distribution fits better (Chi-square goodness of fit test) than Normal distribution. So for this study purpose, flood magnitude, its frequency and return periods are taken from the Gumble distribution (Table 1).

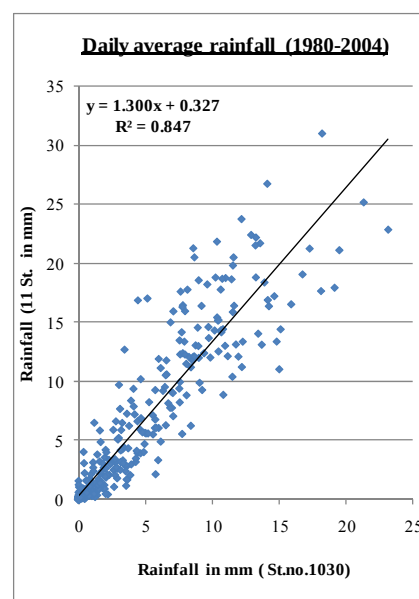


Fig.2 Rainfall correlation

Table 1 Recurrence interval and flood magnitude of Gumbel distribution.

Return Period T_r (Year)	1.58	2	2.33	5	10	20	25	50	100	200	387	500	1000
Flood magnitude $Q(m^3/sec)$	2688	3511	3985	6043	7719	9327	9837	11408	12968	14522	16000	16572	18122

Flood forecasting modeling

The best fitted model for the study area is

$$S_{8am(t)} = C_1 S_{8am(t-1)} + C_2 S_{av(t-2)} + C_3 R_{t-1}$$

Where,

$S_{8am(t)}$ = Stage at 8 am at forecasting time t

$S_{8am(t-1)}$ = Stage at 8 am at time $t-1$, i.e. previous day

$S_{av(t-2)}$ = Average Stage (average of 8am, 12 midday and 4pm stages) of time $t-2$, i.e. two days before

R_{t-1} = Mean rainfall over an area of eleven rainfall stations of last 24 hours. (8 am of the day to 8 am of previous day)

Observed stage value of time t is modeled with observed values of time $t-1$, $t-2$ and rainfall of past 24 hours. This model considers the effect of both rainfall and stage for flood forecasting. Previous day stage at 8 am ($S_{8am(t-1)}$) and past 24 hours rainfall (R_{t-1}) considers the effect of both rainfall and stage of the past 24 hours in the model. Whereas, in order to simplify the model parameters to the community level people, average stage of two days before ($S_{av(t-2)}$) is used. When modeling was done, this combination of model parameters gave the better result so modelings with these parameters are adopted in this study. In order to set up the model and to find the coefficients with least square methods of error minimization, stepwise modeling was performed. First of all modeling was done for complete data sets. As the extreme flood events occur during May to October and floods are called extreme when the stages values are higher (Fig. 3 & Fig.4),

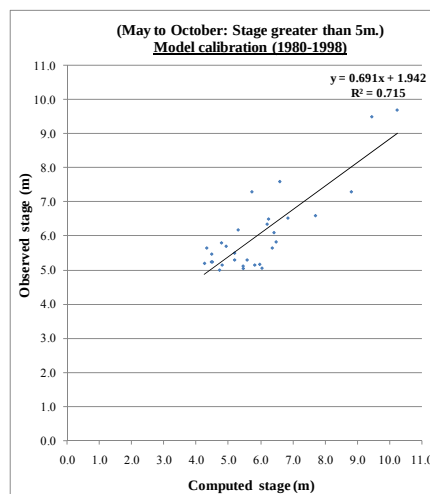


Fig.3 Model calibration

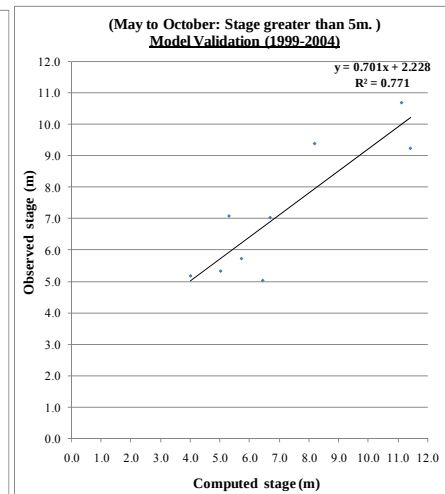


Fig.4 Model validation

Floods with stages value higher than 5m were separated for modelling and coefficients were determined. The model coefficients, R^2 , MBE and RMSE of the analysis are presented in the Table 2

Table 2 R^2 , model coefficients & errors of model calibration & validation

Calibration and validation with stage greater than 5m. (May to October)

Calibration (1980 to 1998)				Model coefficients			Validation (1999 to 2004)			
R^2	MBE (m)	RMSE (m)	(RMSE/Av.Stage) (%)	C_1	C_2	C_3	R^2	MBE (m)	RMSE (m)	(RMSE/Av.Stage) (%)
0.72	0.11	0.715	12.98	0.5958	0.6435	0.0229	0.77	0.10	1.15	15.93

Knowing these model coefficients, stages can be predicted. DHM has given stage and discharge values to define the rating curve for the period 1999 to 2006. Using these values and hqrating software (Goutam, 2007), rating curve is defined to calculate the discharge.

$$Q = 87.796 (S_{8am(t)} - 0.668)^{1.856}$$

So, using this stage discharge relationship, flood magnitude can be calculated, when the stage is known.

Flood characteristics and Inundation analysis

Inundation depth simulation of 1993 flood condition (T_r 387)

Inundation simulation result of 1993 flood condition is presented in Fig.5. Simulation results are compared with the available field inundation depth of year 1993 (at Bhranhapuri and Hathial VDC) and found to be closely approach the past inundation depths. In order to develop the relationship between flood discharges versus inundation depth, simulation was further elaborated with flood of different recurrent interval. Result of simulation is plotted for four village road junction point at Bhrahmapuri tola (ward no.8) & Belbichuwa (ward no.1,2&9) VDC (Fig.6). Using this relationship; even the community level people can identify the depth of inundation at that particular place for forecasted flood of different magnitude.

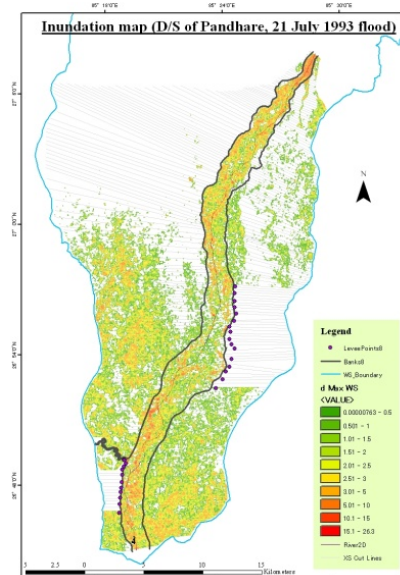


Fig.5 1993 flood condition

$$\text{Inundation Depth} = 0.30778 e^{0.00011*(Q)}$$

Exponential plot is found better fitted. Without incorporating 1993 flood (i.e. T_r 387), linear plot was found best fitted.

$$\text{Inundation Depth} = 8E-05*(Q) + 0.146$$

Such relationship can be developed for even for other places within the downstream reach of watershed boundary. With these graphs, inundation depths can be identified for particular magnitude of flood.

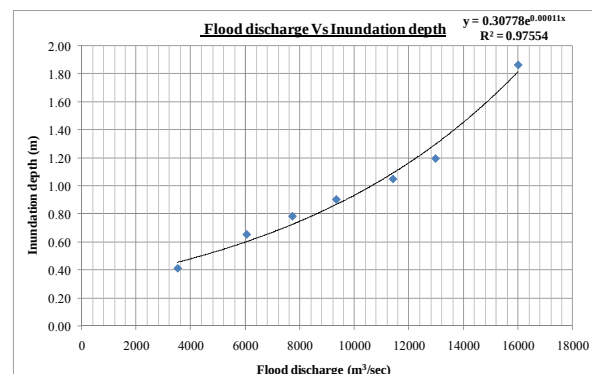


Fig.6 Inundation depth Vs Flood discharge

Inundation analysis of Levee breach condition

Result of complete levee protection and breaching at one point is shown in Fig.7. Inundation depth simulation result of levee breach at Deviparsa and Matsuri village (Near temple at Matsuri village ward no. 5) shows the greater depth of inundation than 1993 flood condition. Depth of inundation found higher, if the area is fully protected from levee and levee breaches at particular area.

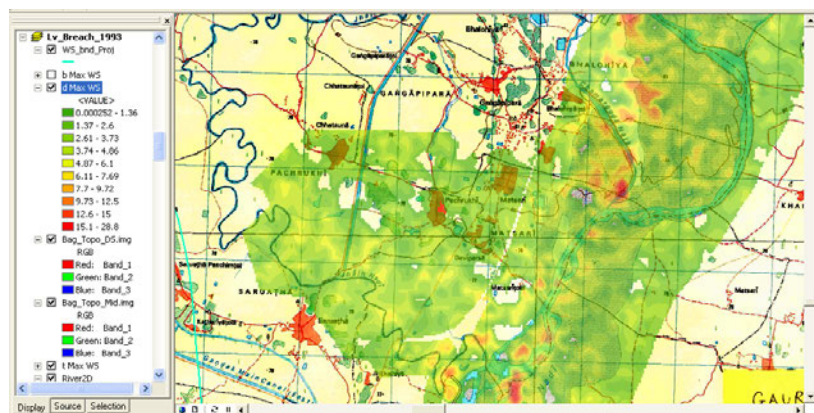


Fig.7 Levee breach condition

In order to develop the relationship between flood discharges versus inundation depth, simulation was further elaborated with flood of different recurrent interval for levee breaching condition (Fig.8). These graphs are useful to identify depth of inundation for particular magnitude of flood when the levee breaches.

$$\text{Inundation Depth} = 0.96189e^{0.00008*(Q)}$$

In order to find the inundation depth for particular magnitude of flood, such relation can be developed for other places of inundation area.

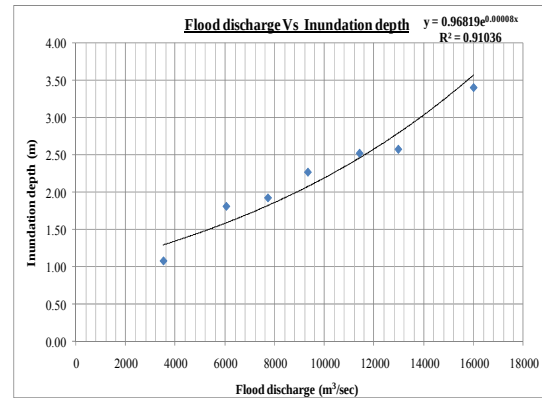


Fig.8 Inundation depth Vs Flood discharge

CONCLUSIONS

Performed analysis of hydrological condition, rainfall runoff modeling and inundation analysis are very much useful tools for flood risk assessment and community approach of flood risk management for the Terai region of Bagmati river basin. With an application of these technique, rainfall of one precise station is can be correlated with rainfall over an area. Knowing rainfall over an area and measured past stages, stage can be predicted using the developed flood forecasting model and identified model coefficients. Once the stage is predicted, probable flood can be calculated using rating curve. Ultimately, developed flood magnitude versus inundation depth graphs can be utilized to identify the depth of inundation for particular magnitude of flood. Such analysis could be done for other river basins as well.

RECOMMENDATION

Further study should be conducted using advance GIS based numerical models and digital data together with precise field observation data. It would be worthwhile to

- i. Validate the result with more field observed data.
- ii. Analyze with more precise data and advance simulation models.
- iii. Develop inundation depth identifying technique for wider areas.

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FLOOD HAZARD AND RISK ASSESSMENT IN MID-EASTERN PART OF DHAKA, BANGLADESH

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ABSTRACT

An inundation simulation has been done for the mid-eastern Dhaka (37.16 km²) on the basis of Digital Elevation Model (DEM) data from Shuttle Radar Topography Mission (SRTM) and the observed flood data for 32 years (1972-2004). The topography of the project area has been considerably changed due to rapid land-filling by land developers. So, collected DEM data has been modified according to the recent satellite image. The inundation simulation has been conducted using HEC-RAS program for 100 year flood. Both present natural condition and condition after construction of proposed levee (top elevation ranges from 8.60 m to 9.00 m) have been considered for simulation. The simulation has revealed that the maximum depth is 7.55 m at the south-eastern part of that area and affected area is more than 50%.

Finally, according to the simulation result, a Flood Hazard Map has been prepared using the software ArcGIS. And risk assessment has been done and a Risk Map has been prepared for this area.

Keywords: Inundation simulation, Flood Hazard, Risk Map

INTRODUCTION

Dhaka is the largest and densely populated city in Bangladesh. The main natural hazards affecting Dhaka include floods, which are associated with river water overflow and rain water stagnation. In fact it is observed that some 60% of the Greater Dhaka East area regularly goes under water every year between June and October due to lack of flood protection in that area.

In 1991, JICA and ADB conducted feasibility study on this area. And in 2006, Halcrow Group Limited, UK, have done a study for updating/upgrading the Feasibility Study of Dhaka Integrated Flood Control Embankment. They divided the whole eastern part of Dhaka into three compartments. They proposed some structural measures which includes construction of embankment, flood wall, pump station and buildup of some pond area. But non-structural measures like preparation of Flood hazard map has not included. In this paper, middle part (compartment-2) is selected as study area and the main objective of this study is to do Flood hazard and risk assessment of that area.

DATA

For this study two types of data have been used. Topographic data which includes DEM (Fig. 1), satellite image (Fig. 2) and river cross-section and hydrologic data covering rainfall, discharge and water level etc. And two software are used; ArcGIS (ESRI, 1999) for DEM data processing & mapping and HEC-RAS (Hydrologic Engineering Center, 2002) for hydrologic simulation.

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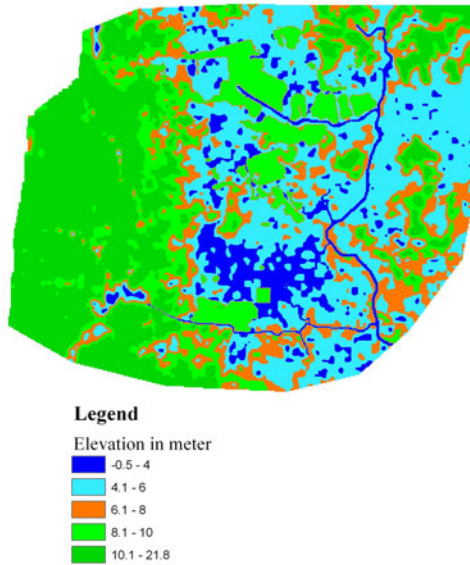


Fig. 1 Digital Elevation Model (DEM) of study area



Fig. 2 Satellite Image of the study area

METHODOLOGY

The methodology can be divided into three phases: Preparation Phase, Execution Phase and Verification & Flood Hazard Mapping Phase (Flow chart shown in Fig. 3). Some important steps of these phases have been briefly described below.

Geo-referencing and Projection

Collected Satellite image has been Geo-referenced according to the geographic coordinate system (GCS_WGS_1984). DEM was also in geographical coordinate system. Geographic coordinate systems indicate location using longitude and latitude based on a sphere (or spheroid) while projected coordinate systems use X and Y based on a plane. Projections manage the distortion that is inevitable when a spherical earth is viewed as a flat map. Projected coordinate system used for this study is WGS_1984_UTM_Zone_45N which is suitable for Bangladesh.

DEM Modification

Grid resolution of collected DEM data is 90 m. The average width of the Balu river (passes through the study area) is around 100 m. So it is difficult to find elevation value on the river path line in that 90 m resolution DEM data. Another problem I faced was that the obtained DEM data was based on satellite image of year 2000. After that, a lot of land development work have been completed in this area which is observed in recent satellite image. So the DEM has been modified according to current topography. The steps are briefly described below.

1. In DEM, elevation values are integer format. So the DEM has been converted to float format.
2. The 90 m DEM has been re-sampled to 30 m resolution DEM using Bilinear interpolation method.

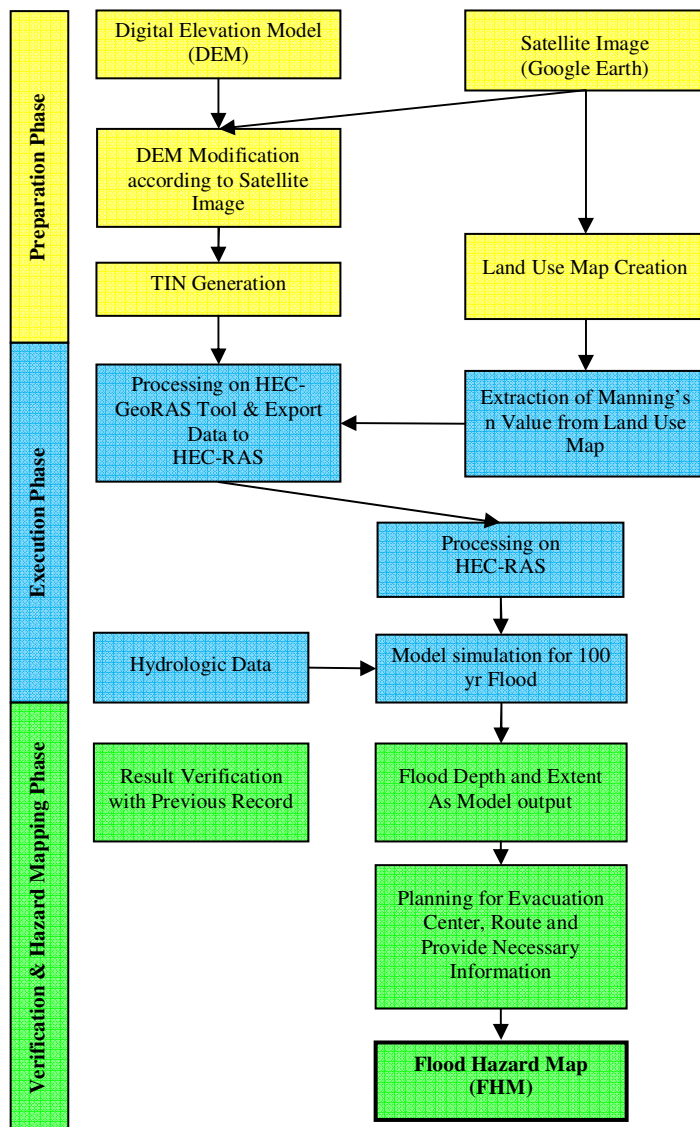


Fig. 3 Flow Chart of Methodology

Processing on HEC-RAS

In HEC-RAS the geometric data has been imported which was exported from ArcGIS by HEC-GeoRAS tool. Main job in HEC-RAS is giving hydrologic data and assigning boundary condition and initial condition. From historical record it is observed that water level in this area reached maximum in 1988. The maximum water level has been input here as boundary condition. At upstream given water level is 7.2 m and at downstream it is 7.05 m. Initial flow 100 m³/s is given as initial condition. According to this condition a maximum inundation depth in every 20 m has been calculated for this area. Then this data has been exported to the ArcGIS.

SIMULATION RESULT AND OBSERVATIONS

Obtained simulation result (shown in Fig. 5) has been verified with observed inundation depth of 1988 flood and satellite image of just after cyclone “Sidr”. It is observed that inundation depth ranges from 1 to 3 m covers most of the area (64 % with respect to total inundated area). But southern part of the

3. Then the DEM data through the river path has been extracted and converted into ASCII format and finally modified the elevation according to actual cross-section of the river in Microsoft Excel.
4. The DEM data of land filled area has also been extracted by observing recent satellite image and then raised the elevation.
5. Finally the modified DEM has been merged with the original DEM.

The DEM both before modification and after modification is shown in Fig. 4.

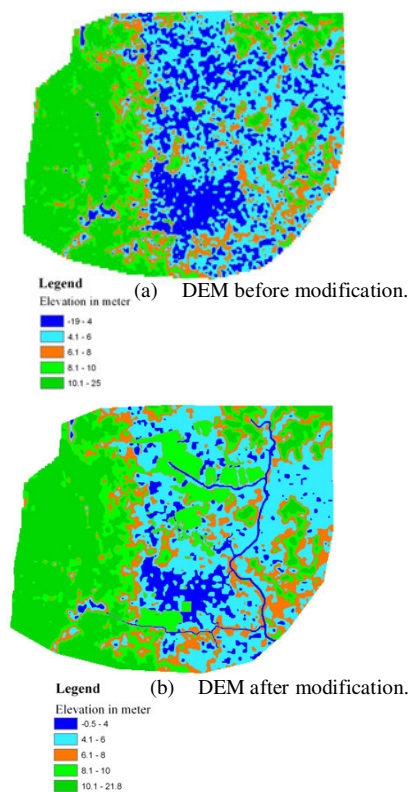


Fig. 4 DEM for both before and after modification

study area is relatively low-lying where inundation depth is more than 3 m. However, buildup area located in western part is mostly unaffected due to higher topography. Percentage inundated area in the study area (compartment-2 shown in encircled by red line) is 54.5 %. Result obtained from this analysis is presented in Table 1.

Table 1 Percentage area inundated according to varying inundation depth

Inundation Depth	Inundated area (sq. km)	% with respect to total inundated area	% with respect to whole area
4 m or higher	1.09	5	3
3 to less than 4 m	3.33	16	9
2 to less than 3 m	7.01	35	19
1 to less than 2 m	5.84	29	16
Less than 1 m	2.97	15	8
Total	20.24	100	54.5

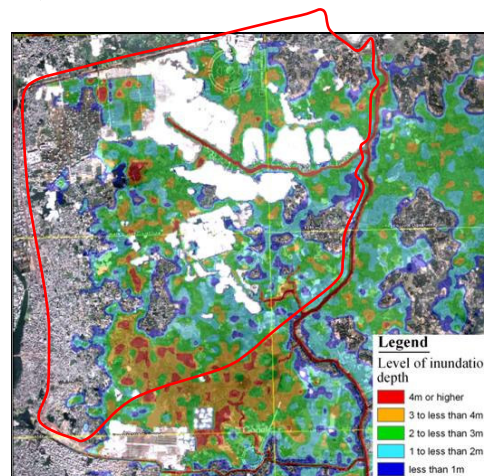


Fig. 5 Inundation status obtained from Simulation

FLOOD HAZARD MAPPING AND RISK ASSESSMENT

Preparation of Flood Hazard Map

A Flood Hazard Map has been prepared using the inundation status which was found from hydrologic simulation, as shown in Fig. 6. According to inundation depth the whole area has been divided into five categories. Some evacuation centers have been proposed in the high area. Some important places such as hospital and police box have been marked in this map which are identified from satellite image.

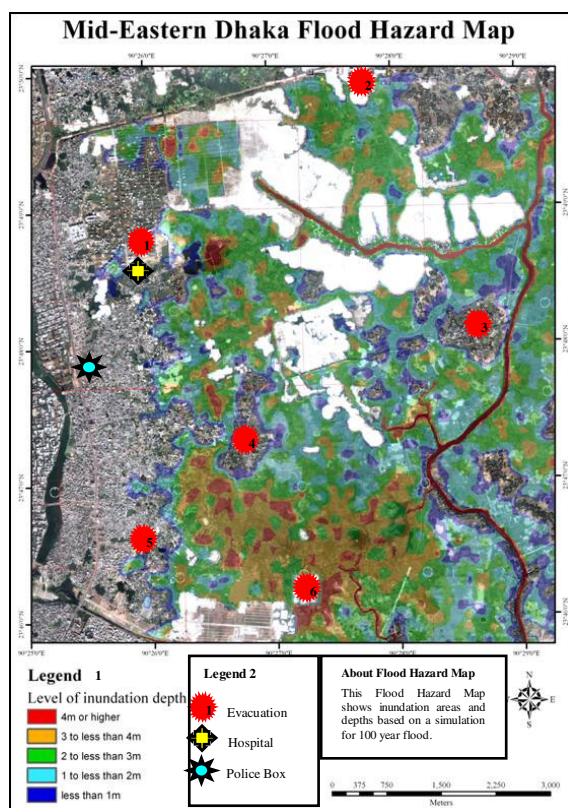


Fig. 6 Flood Hazard Map of Mid-eastern part of Dhaka

Risk Assessment

The risk faced by people must be seen as a cross-cutting combination of vulnerability and hazard. Disasters are a result of the interaction of both; there cannot be a disaster if there are hazards but vulnerability is (theoretically) nil, or if there is a vulnerable population but no hazard event (Wisner B. ; Blaikie P. ; Cannon T. and Davis I., 2004). These three elements: risk (R), vulnerability (V), and hazard (H), can be written in a simple form:

$$R = H \times V \quad (1)$$

Risk Map

In this study an attempt has been taken to make a Risk Map. Risk index has been calculated by multiplying vulnerability and hazard index. Average depth of inundation has been assigned as hazard index. And for calculating vulnerability index,

percentage of area covered with house/living place and agricultural land have been considered. The followed steps are described below:

1. The whole study area has been divided into 300m - 300m block. Total number of block is 624.
2. For calculating average inundation depth in each block, obtained 20m-20m resolution inundation map has been re-sampled to 300m resolution using Bilinear interpolation method.
3. For each block an integer value ranging from 0 to 5 has been assigned as a Hazard index according to inundation depth (shown in (Table 2)).
4. For Vulnerability index, a value ranging from 0 to 10 has been calculated for each block. Weight factor 10 and 2 used for area covered by house and agricultural land respectively. Equation 2 has been used for calculating Vulnerability Index.

Table 2 Assigned Hazard Index (H) for varying inundation depth

Inundation Depth	Hazard Index (H)
No inundation	0
Less than 1 m	1
1 to less than 2 m	2
2 to less than 3 m	3
3 to less than 4 m	4
4 m or more	5

5. A Risk index for each block has been calculated by multiplying Hazard and Vulnerability index (Equation 3).
6. Then these Risk values have been converted to raster format and imported to ArcGIS.

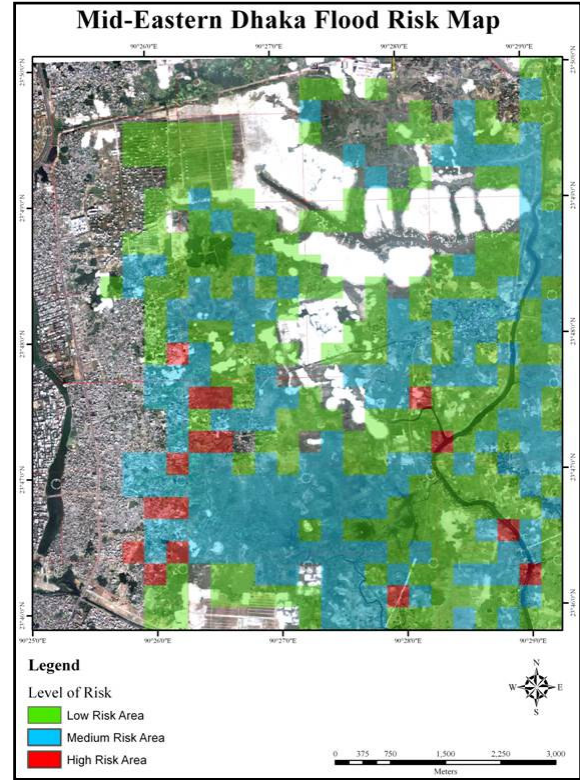


Fig 7 Risk Map of Mid-eastern part of Dhaka

$$V_{\text{Index}} = \frac{10 \times A_{\text{House}} + 2 \times A_{\text{Agriculture}} + 0 \times A_{\text{No Use}}}{A_{\text{Total}}} \quad (2)$$

Where V_{Index} = Vulnerability Index (ranging from 0 to 10)
 A_{House} = Area Covered by House/Living Place
 $A_{\text{Agriculture}}$ = Area Covered by Agricultural Land
 $A_{\text{No Use}}$ = Area used for neither Living nor Agricultural
 A_{Total} = Total Area of each Block

$$R_{\text{Index}} = H_{\text{Index}} \times V_{\text{Index}} \quad (3)$$

Where R_{Index} = Risk Index (ranging from 0 to 50)
 H_{Index} = Hazard Index (ranging from 0 to 5)
 V_{Index} = Vulnerability Index (ranging from 0 to 10)

Table 3 Area classification according to Risk Index

Risk Index	Level of Risk
1 to less than 5	Low risk area
5 to less than 10	Medium risk area
More than 10	High risk area

7. A Risk Map (Fig. 7) has been prepared by classifying into three categories: Low, Medium and High risk area according to Risk index (Table 3).

CONCLUSION

It is observed in Risk Map that high risk zone covers very few areas and it is located mostly near river bank and in transitional zone between western built up area and low-lying area. In this area risk is high because, area coverage with houses is high this means population density is also high in the area. High risk area represents the area where people are more exposed to hazard than those living in other locations.

It is observed that western built up area is completely risk-free though the area is densely populated. There is no inundation in this area and it means risk index is zero. Southern area where inundation depth is maximum, falls in medium risk category though no people living there. Because this area mostly covered by agricultural field.

RECOMMENDATION

The objective of Flood Hazard Map is to provide residents with the information on the range of possible damage and the disaster prevention activities. The effective use of Hazard Map can decrease the magnitude of disasters. From the resident point of view, it is an effective tool to reduce flood damage. On the other hand, Flood Risk Map represents the current scenario of that area according to degree of risk. This is very much useful for government. By using it government can prioritize some area according to degree of risk. In emergency, government can take necessary steps as soon as possible according to priority basis. As land development and urbanization is going on that area both maps should be updated regularly. The following recommendations are made for upgrading these maps:

1. Rainfall, evaporation, percolation which are ignored in current study can be included for further studies.
2. Town watching, conversation with local people and survey are very important work for making an effective Flood Hazard Map. But this work could not be performed for this study. For future studies this should be conducted.
3. For risk mapping, Hazard index has been assigned according to inundation depth. But other factors such as frequency of flood, duration of flood, etc. should be considered. For assigning Vulnerability index, two factors such as percentage of area covered with house and agricultural field have been considered. But there are lots of factors other than that responsible for degree of vulnerability which should be considered for future studies.

ACKNOWLEDGEMENT

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FLOOD RISK ANALYSIS AND RISK MANAGEMENT in MENGWA DETENTION BASIN

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ABSTRACT

Detention basin, as one essential part of flood management measures, is usually designed to store flood temporarily in an extreme flood event for relieving the danger of embankments collapse and ensuring the safety of downstream areas. Mengwa detention basin is the study area of this thesis.

First of all, the study is setting out to make an analysis of flood risk over a typical detention basin to define under which condition Mengwa will be used and calculate how much water is to be diverted into Mengwa for different return period flood.

Secondly, four Flood Hazard Maps for 10year, 20year, 50year, 100 return year period floods are made by HEC-RAS and Arc-GIS, based on the diversion water of different return period flood calculated from the above procedure. Maps will show different inundation areas and inundation depths in the detention basin under a given scenario.

Finally, some proper suggestions like raising residents' risk awareness, making reasonable land use plan, launching flood insurance, will be provided to help reduce the damage from flood in Mengwa detention basin.

Keywords: Risk analysis, Risk management, Mengwa detention basin

INTRODUCTION

Mengwa, the first detention basin built in 1952 in Huai River Basin, lies on the north bank of middle Huai River. There are 157,800 people living inside this area with a total area of 180.4km². Since Mengwa being built, it has been operated 15 times in 12 years, making Mengwa Detention Basin the most frequently used detention basin among all the 97 detention area in China. To mitigate flood damage in the detention basin is the core and objective of this dissertation.

DATA

In this study, 1952-2007 records of annual highest water level and annual peak discharge of the Huai River at Gauge Station is collected for hydrological analysis and calculation. Digital Elevation Model data (DEM) data that is necessary for making Flood Hazard Map is downloaded from the U.S. Geological Survey website, <http://edc.usgs.gov/products/elevation/gtopo30/gtopo30.html>.

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THEORY AND METHODOLOGY

1. Hydrological Analysis and Calculation

By hydrological analysis and calculation, the following two items will be defined:

- the possibility of the operation of detention basin;
- water volume to be diverted into the basin for different return period flood.

1.1 Frequency Analysis

Frequency curve is plotted based on annual peak discharge data at Gauge Station by using K.Pearson III Distribution to find the possibility of operation of Mengwa.

1.2 Hydrograph of Sluice Gate

Water volume to be diverted into the detention basin for each return period flood is obtained from the hydrograph of sluice gate.

(1) Obtain Design Hydrograph

Design hydrographs for each return period flood is obtained by enlarging typical hydrograph in the same scale which is equal to the ratio of peak discharges of typical hydrograph and design hydrograph.

$$K_p = \frac{Q_{mp}}{Q_{mt}} \dots\dots\dots (1)$$

where K_p is enlarging coefficient, Q_{mp} is peak discharge of certain magnitude flood, Q_{mt} is peak discharge of typical hydrograph, which is equal to $7170\text{m}^3/\text{s}$.

By comparison and analysis, the hydrograph in July 11th-15th, 2005 is chosen as the typical hydrograph. The hydrograph is representative since this scenario presents a situation where water diversion was not initiated even though flood heights reached 29m, thus showing a similar case as those where water diversion work should be done. And all of the discharge data comes from actually measurements of velocity and cross section area.

(2) Calculate the hydrograph of Sluice Gate

Stage-Discharge Curve of Gauge Station

$$Q_1 = \text{Exp} \frac{(H - 11.483)}{2.0147} \dots\dots\dots (2)$$

where Q_1 is the discharge in the mainstream, H is the water level in the mainstream.

Stage-Discharge Curve of Sluice Gate

$$Q_2 = 0.32 \times 104 \times 19.6^{0.5} \times (H - 24.46)^{1.5} \dots\dots\dots (3)$$

where H is water level at Gauge Station. Q_2 is discharge of Sluice Gate. The maximum designed discharge of gate is $1799\text{m}^3/\text{s}$, and the corresponding water level H is 29.76m, i.e. even though water level H is rising after reaching 29.76m, discharge Q_2 still remains $1799\text{m}^3/\text{s}$.

Considering the very close distance between Sluice Gate and Gauge Station, it is assumed that the water level at Gauge Station is the same as that at Sluice Gate during water diversion. When the detention basin is operated, discharge in the mainstream will be divided into two parts, discharge Q_1 in the mainstream and discharge Q_2 in the detention basin. Design discharge Q is obtained from the design hydrograph, so water level in the mainstream with time can be obtained by solving the equation $Q=(2)+(3)$. Repeating the same procedure, we can get different water levels at different time until water level goes below 29m at the time when the Sluice Gate will be closed. If the water level is known, it's easy to obtain the hydrograph of Sluice Gate using the equation (3).

2. Make Flood Hazard Map

ArcGIS9.1 and HEC-RAS3.1.3 are chosen for calculating and viewing the inundation depth and area in Mengwa.

RESULTS AND DISCUSSIONS

Frequency curve

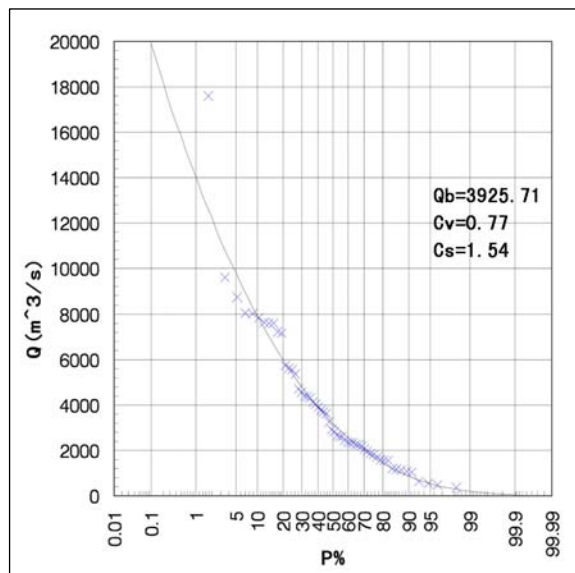


Fig. 1 Frequency curve

The line in Fig.1 is the frequency curve.

According to the utilization scheme of Mengwa, the water level of 29m in the mainstream is a crucial point to decide whether or not to use Mengwa. From Equation (1), we know the discharge is about 5970m³/s when water level reaches 29m. From Fig.1, we know the probability is 20.20% when the discharge is 5970 m³/s. That means Mengwa will leave open the possibility that it will be used when more than 5-year return period flood comes. Table 1 is obtained from Fig.1, showing the relationship of flood probability, return period, peak discharge and highest water level.

Table 1 The relationship of Probability, return period, discharge and water level

Probability	1%	2%	5%	10%	20%
Return Period	100year	50year	20year	10year	5year
Peak discharge(m ³ /s)	14063	12262	9837	7951	5995
Highest water level(m)	31	30	30	30	29

Enlarging coefficient K_p and water volume to be diverted

Table 2 The relationship of return period, K_p and water volume

Return Period	10year	20year	50year	100year
Enlarging coeffecient K_p	1.1089	1.3719	1.7102	1.9614
Water volume	0.211	0.372	0.557	0.638

to be diverted(billion m ³)				
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Design hydrograph and hydrograph of Sluice Gate for different return period flood

In Table 3 Q is the design discharge, Q₂ is the discharge at the sluice gate under the condition of the operation of the detention basin. The time interval is 2 hours.

Table 3 Discharge at different time during the usage of Mengwa

10-year return period flood								
Time	Q	Q _{2(ti)}	Time	Q	Q _{2(ti)}	Time	Q	Q _{2(ti)}
1	5600.19	0.00	9	7124.99	1387.76	17	7744.89	1472.14
2	5994.97	1218.70	10	7152.71	1391.49	18	7829.17	1483.57
3	6157.99	1244.71	11	7180.44	1395.23	19	7951.16	1499.35
4	6387.54	1279.99	12	7215.92	1400.38	20	7934.52	1497.44
5	6587.15	1309.63	13	7493.16	1438.47	21	7779.27	1476.90
6	6698.05	1326.15	14	7626.24	1456.46	22	7640.65	1458.35
7	6853.30	1147.01	15	7642.87	1458.83	23	7274.70	1408.81
8	6997.46	1369.59	16	7627.34	1456.46	24	7075.09	0.00
20-year return period flood								
Time	Q	Q _{2(ti)}	Time	Q	Q _{2(ti)}	Time	Q	Q _{2(ti)}
1	5838.95	0.00	13	8814.68	1607.41	25	9624.12	1701.93
2	6105.11	1236.17	14	8848.97	1611.82	26	9452.63	1682.49
3	6393.21	1280.90	15	8883.27	1615.75	27	8999.89	1630.01
4	6667.60	1321.55	16	8927.17	1621.15	28	8752.94	1600.06
5	6928.27	1359.85	17	9270.16	1661.63	29	8493.64	1568.36
6	7416.68	1428.09	18	9434.79	1680.50	30	8364.68	1552.34
7	7618.35	1455.51	19	9455.37	1682.98	31	8234.35	1535.90
8	7902.34	1493.13	20	9436.16	1680.50	32	8112.25	1520.47
9	8149.29	1524.81	21	9581.59	1697.44	33	8014.84	1507.98
10	8286.48	1542.18	22	9685.85	1708.93	34	7916.06	1495.04
11	8478.55	1566.41	23	9836.77	1725.97	35	7381.00	1423.38
12	8656.90	1588.33	24	9816.19	1723.46	36	7298.69	0.00
50-year return period flood								
Time	Q	Q _{2(ti)}	Time	Q	Q _{2(ti)}	Time	Q	Q _{2(ti)}
1	5746.37	0.00	18	11073.73	1799.00	35	10112.58	1755.67
2	6020.01	1222.72	19	11128.46	1799.00	36	9991.16	1742.56
3	6635.69	1316.96	20	11556.02	1799.00	37	9868.02	1728.98
4	7278.73	1408.81	21	11761.24	1799.00	38	9201.03	1653.21
5	7610.52	1454.08	22	11786.90	1799.00	39	9098.42	1641.35
6	7969.67	1501.27	23	11762.96	1799.00	40	9081.32	1639.38
7	8311.71	1545.56	24	11944.24	1799.00	41	8841.88	1610.84
8	8636.66	1585.89	25	12074.22	1799.00	42	8653.76	1587.84
9	9245.50	1658.66	26	12262.34	1799.00	43	8380.12	1553.79
10	9496.90	1686.97	27	12236.69	1799.00	44	8072.28	1515.18
11	9850.92	1726.97	28	11997.26	1799.00	45	7880.74	1490.26
12	10158.76	1760.72	29	11783.48	1799.00	46	7690.90	1465.00
13	10329.78	1778.94	30	11219.10	1799.00	47	7501.06	1439.41
14	10569.22	1799.00	31	10911.26	1799.00	48	7179.54	1395.70
15	10791.54	1799.00	32	10588.03	1799.00	49	6858.02	0.00

16	10988.22	1799.00	33	10427.27	1789.60			
17	11030.98	1799.00	34	10264.79	1772.35			
100-year return period flood								
Time	Q	Q _{2(ii)}	Time	Q	Q _{2(ii)}	Time	Q	Q _{2(ii)}
1	5589.99	0.00	20	12651.03	1799.00	39	11458.50	1799.00
2	6001.88	1220.04	21	12700.07	1799.00	40	11317.28	1799.00
3	6296.09	1265.93	22	12762.83	1799.00	41	10552.33	1799.00
4	6590.30	1310.09	23	13253.18	1799.00	42	10434.65	1790.61
5	6904.13	1356.14	24	13488.55	1799.00	43	10415.03	1788.58
6	7610.23	1454.56	25	13517.97	1799.00	44	10140.44	1758.70
7	8347.72	1549.92	26	13490.51	1799.00	45	9924.68	1735.52
8	8728.23	1597.13	27	13698.42	1799.00	46	9610.86	1700.44
9	9140.12	1646.29	28	13847.48	1799.00	47	9257.81	1660.14
10	9532.40	1691.45	29	14063.24	1799.00	48	9038.13	1633.95
11	9905.07	1733.00	30	14033.82	1799.00	49	8820.42	1608.39
12	10603.33	1799.00	31	13759.22	1799.00	50	8602.70	1581.50
13	10891.65	1799.00	32	13514.05	1799.00	51	8233.96	1535.90
14	11297.66	1799.00	33	12866.78	1799.00	52	7865.21	1488.35
15	11650.72	1799.00	34	12513.73	1799.00	53	7584.73	1450.77
16	11846.86	1799.00	35	12143.03	1799.00	54	6845.29	1347.81
17	12121.45	1799.00	36	11958.66	1799.00	55	6507.93	0.00
18	12376.43	1799.00	37	11772.32	1799.00			
19	12602.00	1799.00	38	11597.76	1799.00			

Inundation area and depth

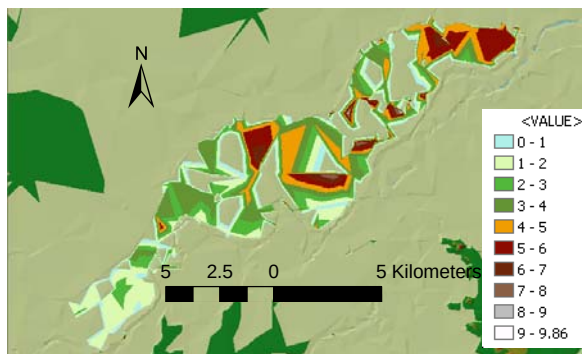


Fig.2 10-year return period flood

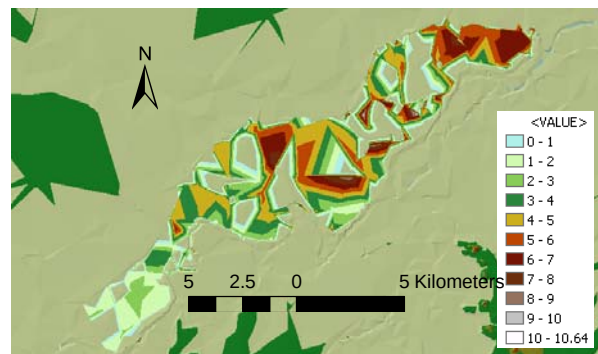


Fig.3 20-year return period flood

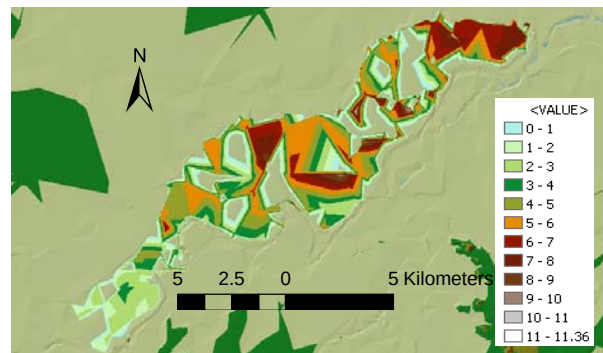
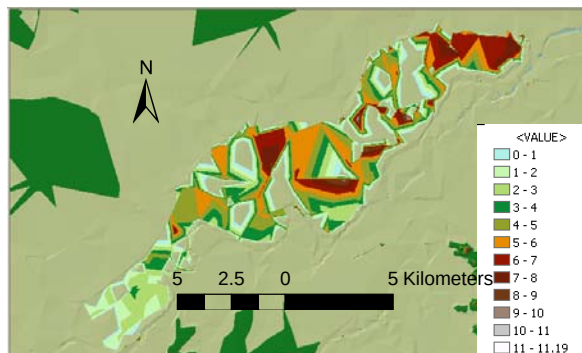


Fig.4 50-year return period flood

Fig.5 100-year return period flood

Application of Flood Hazard Map

Raise Awareness

- Involve residents' participation in the preparation of flood hazard map.
- Distribute flood hazard map to each household and train them how to understand these information on the map.
- Launch some drills which will guide them how to reach safe places as soon as possible by using these information on the hazard map.
- Start with the flood risk education from the elementary school.

Reasonable Land Use Plan

- Land use plan should consider the good protection of people's property and life from flood as the top priority since Mengwa is a detention basin.
- Mengwa area is supposed to be defined as that with different flood risk levels.
- Guide and encourage farmers to plant crops which are not vulnerable to inundation condition.
- Encourage people to build their houses on the places with low flood.
- A participatory approach is recommended in decision-making and implementation of activities because these activities are very closely related with people's benefits.

Flood Insurance Plan

- FHM is the important foundation of the application of flood insurance.
- Flood insurance should be compulsory.
- Flood risk will be shared by Government, society and individuals including especially those who benefit from the utilization of detention basin.

CONCLUSIONS

- ◆ The results on FHM is confirmed to live up to actual inundation situation by calibrating the historical data recorded at some sites inside.
- ◆ The information about inundation area and depth is very crucial and indispensable for the the implementation of these suggestions in the detention basin.
- ◆ Out of the suggestions, the role of land use plan is projected in flood damage mitigation work.
- ◆ A down-top approach is proved to be effective in flood damage mitigation by giving stakeholders the chance to participate in the process of decision-making and implementation of activities.

RECOMMENDATION

- ◆ Field survey in Mengwa Detention Basin is recommended.
- ◆ The vertical resolution of the DEM data is recommended.
- ◆ Due to the limited data, only a rough evaluation and general suggestions are given.

ACKNOWLEDGEMENT

My hearty thanks should be paid to Prof. A.W.Jayawardena who supervised my master thesis with such a great efforts, and Dr. Rabindra Osti. Their patience, kindness and enthusiasm move me.

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ESTABLISHMENT OF COUNTRY-BASED FLOOD RISK INDEX

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ABSTRACT

This thesis offers a measure to assess the country-wise flood risk, namely Flood Risk Index (FRIC), on the basis of Pressure and Release Model (PAR model) which is expressed as the equation of "Risk = Hazard × Vulnerability" (Wisner, B. et al., 2004). In this study, Vulnerability is divided into four components hence Flood Risk Index considers five aspects of flood risk; Hazard, Exposure, Basic Vulnerability, Capacity soft countermeasures and Capacity hard countermeasures. Five components are set as Sub-index and each sub-index is composed of three kinds of datasets which are the most representable variables for each sub-index, namely Indicator. The basic equation of "R=H×V" is modified to calculate Flood Risk Index, which is expressed as;

$$\text{Flood Risk Index (FRIC)} = \frac{\text{Hazard} \times \text{Exposure} \times \text{Basic Vulnerability}}{\text{Capacity} \{= (\text{Soft countermeasures} + \text{Hard countermeasures})/2\}}$$

With an application of FRIC, current potential risk of flood is assessed for 235 countries and regions. FRIC can indicate the structure of flood risk as well. Result of analysis clearly indicates the high-risk countries are in Asia such as Philippines, Myanmar, and Bangladesh, etc. Japan comes under the category of low risk thanks to low vulnerability and high capacity.

Before calculating Flood Risk Index, data of past damages is also analyzed using EM-DAT in terms of number of events, killed people, and average killed people per event. The results are shown as Flood Damage Indicator (FDIa). Accuracy of EM-DAT is also verified by comparing it with Dartmouth database and some country reports.

Finally, FRIC is compared with FDIa in order to assess correlation between them. It is indicated that FRIC has a certain correspondence to FDIa especially in Asian region. Furthermore, we can find high risk countries with less observed flood damage. It can be said that these countries have not been suffering from flood severely but have high potential to be damaged by flood. For instance Myanmar is assessed as a high risk country with a less death toll in the past. It can be said that flood risk in Myanmar was actualized in 2008 with more than 100,000 deaths by the cyclone Nargis. This implies the effectiveness of Flood Risk Index.

Keywords: Flood Risk Index, Risk assessment, Vulnerability, PAR model

INTRODUCTION

The Hyogo Framework for Action, The World Conference on Disaster Reduction (WCDR) held in Kobe, Japan, in January 2005 said that "The development of indicator systems for disaster risk and vulnerability is one of the key activities enabling decision makers to assess the possible impacts of disasters". There are lots of conceptual frameworks and studies to assess the risk or vulnerability to natural disaster (J. Birkmann, ed. 2006). One of the most common and simple conceptual models is the Pressure and Release Model (PAR model). However, there seems to be no study that uses the equation of "Risk = Hazard × Vulnerability" as it is in order to make risk index. If risk index is established using this equation as it is, it would be very understandable, easy to explain, and very informative and valid. The important thing to make index is that it should be simple and easy to understand so that common people can understand their risk or situations.

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Flood occurs at the local level. However it is true that preparedness for natural disaster depends on the national status. For instance, critical infrastructures such as national roads, levees for big rivers, are dealt with at national level. It can be said that flood risk is basically dominated by national status. It is also true that we sometimes talk about flood risk country-wise. For example we generally mention that Bangladesh is high-risk country to flood. In international conversation, we firstly consider national status. So, country-wise flood risk assessment is essential for international activities.

ANALYSIS OF THE PAST FLOOD DAMAGE

As the consequence of the comparative analysis of three kinds of data sources, which are Dartmouth, EM-DAT and Country Report, EM-DAT was accepted for flood damage data analysis. First reason for acceptance of EM-DAT is that it seems to collect the data more widely as compared to Dartmouth database. Secondly agreement with country reports is better than Dartmouth database. Thirdly it is difficult to collect country reports of all countries. The comprehensive database like EM-DAT was essential to make the countries comparable world wide.

Here the dataset of EM-DAT during the past 23 years (from 1985 to 2007) was used to measure the damage level of the past floods. Three kinds of data were used for the measurement; number of events, killed people, and average killed people per event. All events with one killed people or over were classified into three classes by the size of death toll. Data coverage and criteria of three classes are shown in Table 1. To make the countries comparable, variables were converted to the indicators, namely Flood Damage Indicator (FDIa), by the following formula;

$$FDIa = (LN(x) - LN(\text{Min}(x)) / (LN(\text{Max}(x)) - LN(\text{Min}(x))) \quad (1)$$

Where; FDIa ; Flood Damage Indicator (actualized)

x : variables (number of events (noted by N), number of killed people (noted by K), and killed people per event (noted by KperN))

Max(x) : the actual maximum value

Min(x) : the actual minimum value (If x=Min(x), FDIa=0.05)

FDIa_Com is calculated by the addition of FDIa_L, FDIa_M, and FDIa_H.

88 percent of 3,161 events in total were classified in FDIa_L. On the contrary only 13 percent of 432,960 killed people in total were in FDIa_L. On the other hand 65 percent of total number of killed people is in FDIa_H in spite of only 1 percent of total events. This shows that preventing catastrophic events is important to reduce casualties by floods. Fig.1 shows the distribution map of FDIa_Com_K. It is indicated that the countries in Asia and America have been suffering from flood severely.

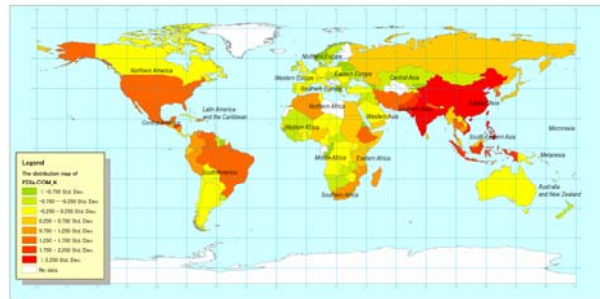


Fig.1 Distribution map of FDIa_Com_K (killed people)

Table 1 Statistics of past flood damage

Class	Criteria (No. of killed people of one event)	Abbrev.	Countries covered	No. of Events (N)	No. of Killed People (K)	Average killed People per event (KperN)
Low	~100	FDIa_L	177 (100%)	2,775 (88%)	54,831 (13%)	19.8
Middle	101~1000	FDIa_M	54 (31%)	345 (11%)	97,408 (22%)	282.3
High	1000~	FDIa_H	15 (8%)	41 (1%)	280,721 (65%)	6,846.9
TOTAL		FDIa_Com	177 (100%)	3,161 (100%)	432,960 (100%)	137.0

*Ratio of each item is the ratio of each value to the total of each item

ESTABLISHMENT OF FLOOD RISK INDEX (FRIC)

Structure of Flood Risk Index (FRIC)

The basic concept of Flood Risk Index (FRIC) is based upon Pressure and Release Model (PAR model); “a disaster is the intersection of two opposing forces which are hazard and vulnerability.” (Wisner, B. et al., 2004). In this study, Vulnerability is divided into four factors hence Flood Risk Index considers five aspects of flood risk; Hazard, Exposure, Basic Vulnerability, Capacity soft countermeasures and Capacity hard countermeasures. Five components are set as Sub-index and each sub-index is composed of three kinds of datasets which are the most representable variables for each sub-index, namely Indicator (see Fig.2).

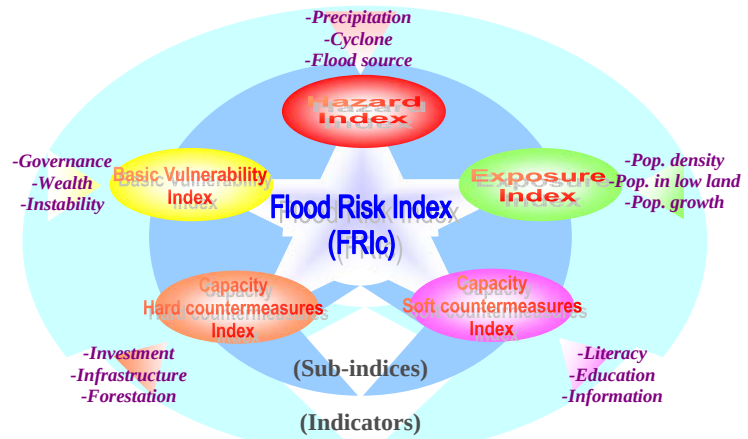


Fig.2 Structure of Flood Risk Index (FRIC)

The equations to calculate indicators, sub-indices, and Flood Risk Index are expressed as follows;

$$\text{Flood Risk Index (FRIC)} = H \times E \times V / C \quad (2)$$

Where; H: Hazard index E: Exposure index V: Basic Vulnerability index

C: Capacity index (= (Capacity Hard countermeasures index
+ Capacity Soft countermeasures index)/2)

$$\text{Indicator} = \{ \ln(x) - \ln(\min(x)) \} / \{ \ln(\max(x)) - \ln(\min(x)) \} \quad (3)$$

$$\text{Sub-Index} = \text{Indicator 1} + \text{Indicator 2} + \text{Indicator 3} \quad (4)$$

Indicators

Indicators are selected by qualitative method; discussion with ICHARM experts, deep consideration, data availability, reviewing early studies. Selected indicators and data used are shown in Table 2. Data are collected from various kinds of sources such as Central Intelligence Agency (CIA), United Nations Common Database (UNCDB), The Food and Agriculture Organization of the United Nations (FAO), JAXA/EORC, Socioeconomic Data and Applications Center (SEDAC), United Nations Development Programme (UNDP).

Table 2 Indicators

Sub-Indices	Indicators	Data
Hazard	1. Precipitation	Average annual precipitation in depth
	2. Cyclone Proneness	Cyclone proneness considering frequency and magnitude
	3. Flood Source	Water area ratio to land area
Exposure	1. Basic Population Density	Population density in the area where population density is more than 5 people per sq. km
	2. Low Land Area's Population Density	Population density in the area where the elevation is below 200m
	3. Population growth	Population in 2005 / in 1985
Basic Vulnerability	1. Governance	Corruption Index
	2. Wealth and information	Life Expectancy
	3. Instability	GINI coefficient
Capacity Hard Countermeasures	1. Potential Investment	GDP per Area
	2. Infrastructure	Paved Road Density
	3. Forestation	Forestation ratio in 2005 – in 1990
Capacity Soft Countermeasures	1. Literacy	Adult literacy rate (%)
	2. Education	Enrolment ratio for education (%)
	3. Information	Television receivers per one thousand inhabitants

Sub-indices (see Fig.3)

Hazard Index

Cyclone prone countries such as those in Asia, North and Central America and South Africa tend to be assessed as with high hazard. Taiwan was calculated as the most hazardous country in the world. Puerto Rico and Bahamas in Latin America and the Caribbean region were ranked at high positions because of the high value of water source indicator.

Exposure Index

Countries with high exposure can be seen mostly in Asian region. As a result of consideration of population density, higher ranks were occupied by small area countries and regions such as Macao, Singapore and Hong Kong. Surprisingly Bangladesh was ranked at number 10 in spite of its larger area of 136,035 sq. km than the other high ranked countries. Regarding other Asian countries, Taiwan was ranked at 20th with its index of 1.564, India was 23rd with 1.538, Japan was 45th 1.401, and China was 53rd with 1.369.

Basic Vulnerability Index

Many European countries, North American countries, Japan and some Oceania countries are assessed as with low Basic Vulnerability and many African countries are high. Top 20 countries except Haiti are occupied by African countries because of high corruption, high disparity, and low life expectancy.

Capacity Hard Countermeasures Index

Japan and many European countries are assessed as with high Capacity Hard Countermeasures and many African countries and South American countries are low. Small land area countries tend to be ranked high, Monaco at 1st, Singapore at 2nd, etc. Netherlands is ranked at 7th and Japan at 13th.

Capacity Soft Countermeasures Index

Canada and many European countries are assessed as with high Capacity Soft Countermeasures and many African countries and several Southwestern Asian countries are low. Only two Asian countries i.e. South Korea and Taiwan are ranked in top 20 countries.

These results seem to be acceptable, convincing and matching our feelings.

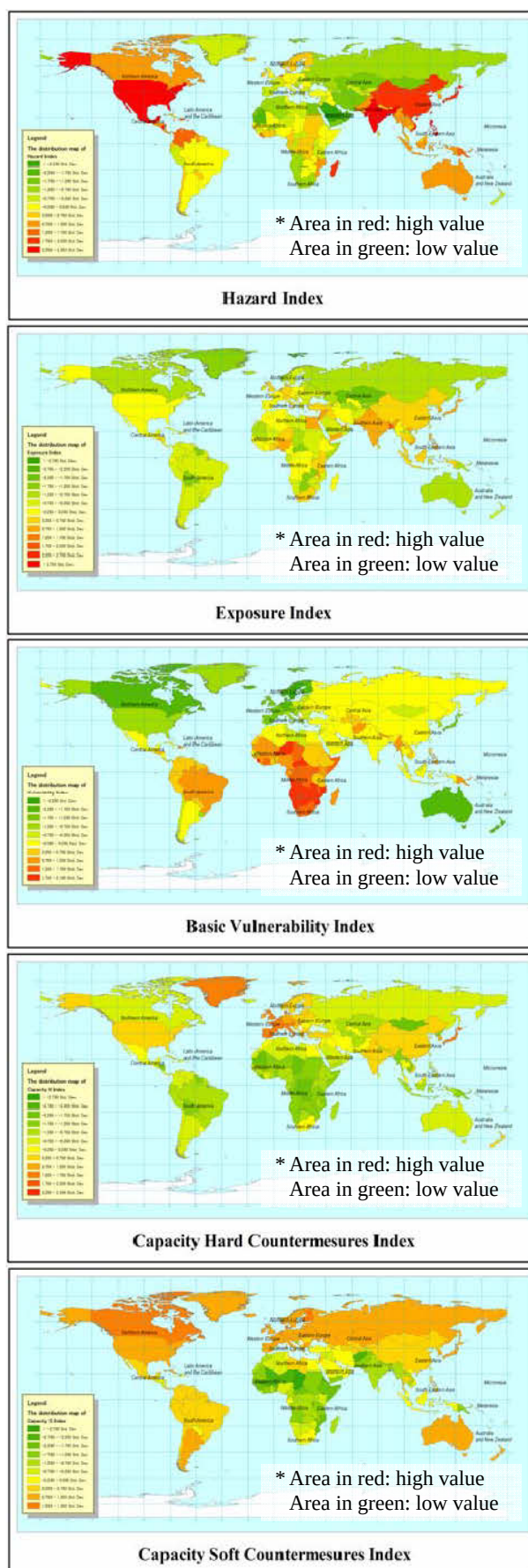


Fig.3 Distribution maps of five Sub-indices

Flood Risk Index (FRIC)

Flood Risk Index (FRIC) is calculated for 235 countries and regions. Fig.4 shows the distribution map of FRIC. A county area in red indicates high flood risk and that in green indicates low flood risk. Asian countries and several African countries are assessed as with high risk of floods. Some Central American countries are also assessed as with high risk of floods.

Haiti is assessed as the most risky country in the world due to high vulnerability and low capacity. Bangladesh stands as the runner up mainly due to its high hazard and high exposure. The places from third to eighth are occupied by African countries such as Mozambique and Gambia. Some other Asian countries are also ranked in this list such as Nepal at 9th, Philippines at 11th, Myanmar at 14th, India at 17th, and Cambodia at 18th. Taiwan is assessed as the most hazardous country. However its rank in Asian counties is 13th thanks to its low vulnerability and high Capacity.

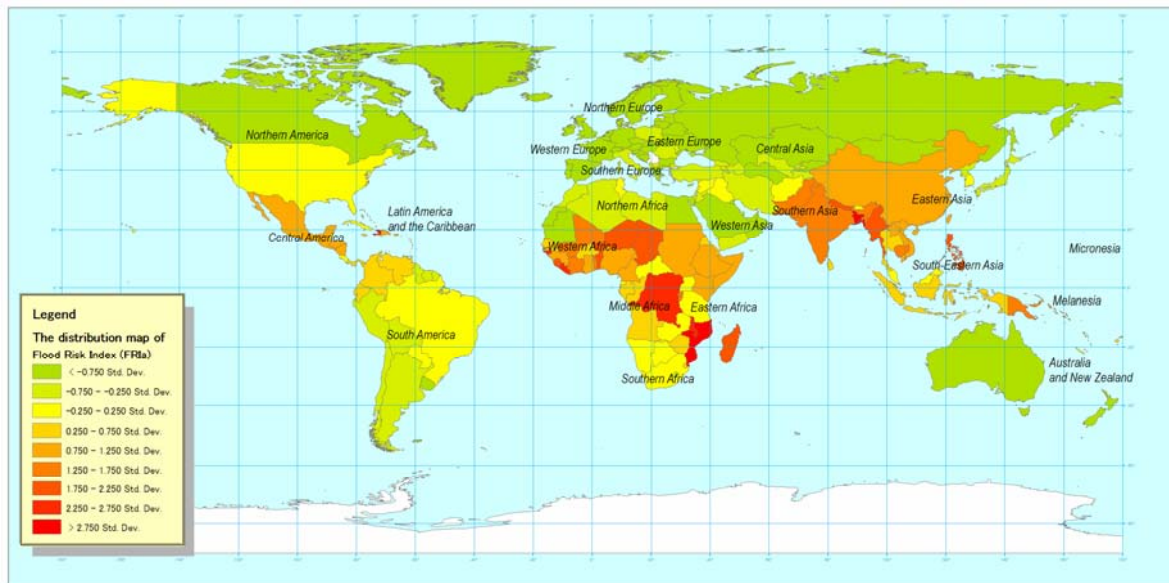


Fig.4 Distribution map of Flood Risk Index (FRIC)

COMPARATIVE ANALYSIS BETWEEN FLOOD RISK INDEX AND PAST FLOOD DAMAGE

Calculated Flood Risk Index (FRIC) is compared with past flood damage data in order to verify agreement. Fig.5 is the scatter graph plotted by Flood Risk Index (FRIC) and Flood Damage Indicator of killed people (FDIa_Com_K). FRIC has certain correspondence with past flood damage but apparently not so significant ($R^2=0.18$). One of the reasons of disagreement is that FRIC expresses the present condition of flood risk whereas FDIa indicates the consequences of past flood. The countries are classified into 8 groups by cluster analysis using FRIC, FDIa_Com_K, and the difference of them in order to make disagreement more clear. The countries in group 1 and 2 are assessed as high risk with less flood damage. In other words they have not

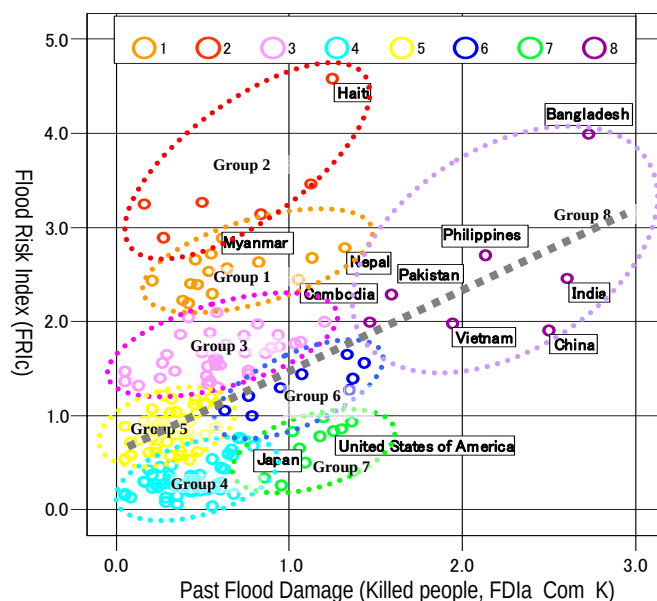


Fig.5 Comparison between FRIC and FDIa_Com_K

been suffering from flood severely in spite of their high risk. For instance, Myanmar in group 1 is assessed as with high risk but had not been damaged by flood severely upto 2007. However, in 2008, risk was actualized. Cyclone Nargis hit Myanmar and brought extremely huge damages with more than 100,000 deaths. It can be said that the countries in group 1 or 2 have not suffered from flood severely but they have high potential to be damaged by flood more severely. This implies the effectiveness of Flood Risk Index of this study.

Another advantage of FRIC is that FRIC can indicate the structure of flood risk. The methodology to make FRIC in this study allows us to analyze the reasons for high or low flood risk. Fig.6 shows the structures of FRIC about Myanmar and Japan. Myanmar and Japan has similar FDia_Com_K (similar number of deaths during past two decades) but FRIC of Myanmar is 2.63 whereas that of Japan is only 0.68. Hazard and Exposure of Japan are higher than those of Myanmar but Flood risk of Japan is assessed as low thanks to high capacity and low vulnerability. Flood risk of Myanmar is assessed as high due to high vulnerability and low capacity. This implies that Japan should make an effort to build capacity continuously otherwise flood risk can easily increase.

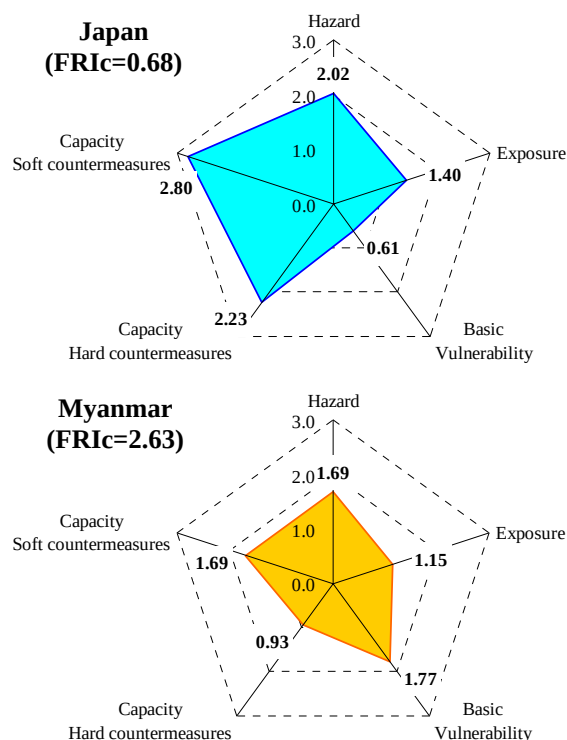


Fig.6 Structures of Flood Risk Index (FRIC)

CONCLUSIONS

Here Country-based Flood Risk Index was successfully established for 235 countries and regions. The advantages of Flood Risk Index are;

- ✓ We can assess flood risk at present time without using past flood damage data
- ✓ We can see the structure of flood risk
- ✓ We can find high risk countries which have not suffered from flood severely.

This methodology to assess flood risk is a new attempt and is very informative and valid. However, the development of how to assess flood risk is still at the initial stage. There are lots of attempts but those studies have both advantages and disadvantages. It is hoped that the outcomes of this thesis will advance our knowledge of flood risk assessment and motivate people to enhance the flood risk management activities.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to Prof. Kuniyoshi Takeuchi of ICHARM and his staff and Prof. Taikan Oki of Tokyo University for their continuous support, valuable suggestion and guidance during my study.

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THE ANALYSIS OF FLOOD RISK AWARENESS AT RESIDENT LEVEL IN MEKONG RIVER BASIN

~focusing on the evacuation behavior~

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ABSTRACT

Mekong River basin has some specific characteristics, such as the fact that the economy is growing rapidly and benefits of fertilization of land for agriculture and fishery are brought by flooding. However in 2000, big flood attacked the downstream area. A lot of people were killed by the flood. In 2006, in mountainous areas, Lao PDR suffered from flash floods. Some people were killed by these floods.

For human damage reduction, "Self Help" and "Mutual Support" are important. One of its activities is evacuation behavior. In this study, the evacuation behavior is focused and occurrence and expansion of flood damage is analyzed.

Two survey areas were selected for this study. One is Luang Namtha in northern part of Lao PDR which was recently reported to be damaged by flash flood and other is Phnom Penh which is frequently hit by flood in rainy season.

At first, expected factors of occurrence and expansion of flood damage were set up by document survey. Then, Questionnaire survey to residents was carried out in two survey area for identification of expected reasons. In addition, interview with residents and community leaders about condition of damages and countermeasures for flood was also held in the field survey. Finally, measures to improve the condition that resident can evacuate safely and adequately were studied and suggested based on the results of field survey and identification of reasons.

As the reasons that residents did not evacuate, distance to the evacuation site from houses and danger of evacuation route were pointed out. Therefore, an appropriate distance to the evacuation site from houses is suggested.

Keywords: Evacuation behavior, Questionnaire survey, Distance to the evacuation site

INTRODUCTION

It is said that there are three items crucial for reducing damage from all kinds of disaster; "Self Help", "Mutual Support" and "Public Assistance". These items mean necessary awareness had and activities done for disaster damage mitigation by residents, community and local government. In Kobe (Hanshin-Awaji) Great Earthquake that occurred in 1995, it can be said that about 65% of survivors were saved through "Self help" activities while about 30% of them were saved through "Mutual Support" activities. Hence, it should be noted that "Self-Help" and "Mutual Support" are indispensable for disaster mitigation.

The evacuation behavior that is one of the important "Self Help" and "Mutual Support" activities is necessary for human damage reduction. It should be done adequately and surely. However, it is not certain that residents follow a warning even if they are recommended evacuation by warning in the

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necessary occasion, because sometimes residents have a little awareness about evacuation. To solve such situation, removal of obstacle causing residents' negative evacuation behavior and giving needed condition that motivate evacuation are required. Therefore it is necessary to grasp residents' basic conception of evacuation behavior.

STUDY AREA

Historically, flood has been regarded as "Benefit" by people in Mekong river basin. However, it can not be denied that in the past flood has brought serious damage which had been aggravated by rapid economic growth, the change in living environment, river development, and climate change by global warming. Most of the floods in the Mekong River Basin can be classified into two types. The first type is a flash flood that occurs in a mountainous area. The second one is a continental type flood.

As a case study area, Mekong River basin which has the above-mentioned characteristics was selected. As survey region, two areas are selected. First region is Luang Namtha in northern mountainous area of Lao PDR which suffered from flash flood in 2006. Second region is Phnom Penh the capital of Kingdom of Cambodia as an urban area which suffered from a big flood in 2000.

For the flood of 2006 in Luang Namtha, Lao PDR, 4 people were killed, 21 houses were collapsed, the inundated area approximated 10km² and 1,916 households were affected (MRC, 2007).

The flood in 2000 inundated the area on the both side of Tonle Sap River in northern part of Phnom Penh, and on the left side of Basacc River for long time. In the whole country, approximately 7,000 houses were collapsed. The duration of inundation was about for 4 months. 347 people were killed in the country. Economic-loss was 150 billion US\$ and about 3.5 million people were affected. (ADRC, 2002)

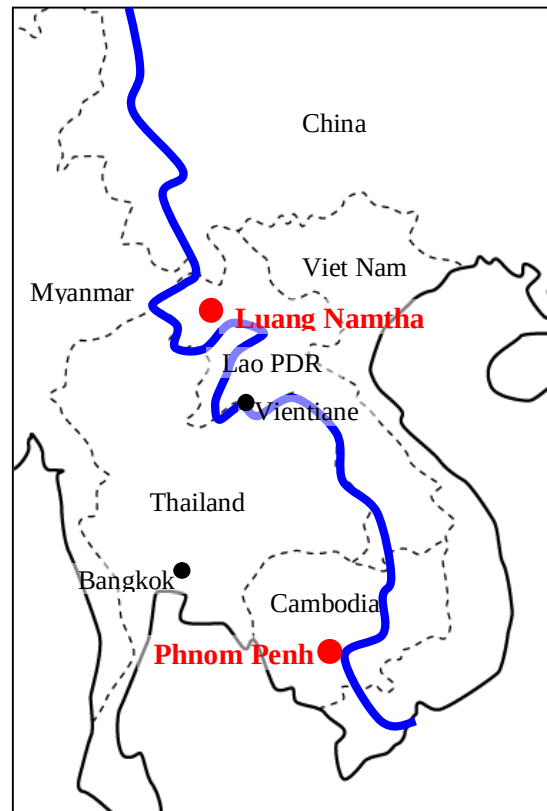


Fig. 1 Map of the survey areas

OBJECTIVES

In this study, the following concrete objectives were considered.

- ✓ Identification of reasons of evacuation behavior of residents by carrying out a questionnaire and interview survey to the residents and community leaders as a field survey
- ✓ Assessment of evacuation behavior controlled by some conditions
- ✓ Identification of flood management to promote effective flood evacuation for residents

FIELD SURVEY

Preparation for questionnaire survey

Reasons of occurrence and expansion of the flood damage are assumed. Reasons should be set on the assumption that it can be identified by the questionnaire and interview survey. As an item which

should be considered, the evacuation behavior of the resident was selected. It has an important role for damage reduction. When a necessary evacuation behavior was not carried out or evacuation behavior was under the imminent situation, the possibility of occurrence and expansion of the flood damage increases. In addition, it is very likely that vulnerability of residents and community for flood disaster lead to the occurrence and expansion of flood damage. Therefore, the following three points about evacuation behavior and vulnerability are set up as the pillar item.

- ✓ A reason causing that resident judged by him or herself evacuation was not necessary
- ✓ A reason causing that a resident could not evacuate even he or she intended to
- ✓ Vulnerability of resident for the flood damage

To reduce the flood damage focusing on the evacuation behavior, it is necessary to identify the reason that residents do not evacuate in flood time. However, residents who did not evacuate were under the various circumstances. Therefore, among residents who did not evacuate, they can be classified into 2 groups. One is residents who judged evacuation was not necessary. Another one is those who could not evacuate because of some obstacles. Such classification was made in some studies which surveyed the flood risk awareness of residents. (NIED 2006, YOSHITANI 2008)

Questionnaire survey

- Questionnaire style
 - In Lao PDR; Distribution and collection style through the chiefs of villages
 - In Cambodia; Individual interview style by author and interpreter
- Target people
 - In Lao PDR; Residents in flooded 3 villages in Luang Namtha province
 - In Cambodia; Residents in flooded 2 areas in Phnom Penh city
- Survey period
 - In Lao PDR; 12th ~ 15th on May 2008
 - In Cambodia; 19th ~ 22nd on May 2008
- Outline of survey

The outline of the questionnaire survey in Luang Namtha, Lao PDR and Phnom Penh, Cambodia is shown in Table 1.

- Structure of questionnaire

The structure of the questionnaire was categorized into 3 sections as shown below.

SECTION 1: The information on respondents

- Q1; Age
- Q2; Gender
- Q3; Number of family people
- Q4; Occupation
- Q5; Period of living
- Q6; Structure of house
- Q7; Number of experience of flood
- Q8; Number of experience of evacuation

Table 1 The outline of the questionnaire survey

CONTENT	VALUE			NOTE
	TOTAL	Lao PDR	Cambodia	
Population	1,811	639	1,172	
Number of Questionnaire distributed	201	100	101	(a)
Number of respondents	193	92	101	(b)
Ratio of respondents	96%	92%	100%	(b)/(a)

SECTION 2: The information on flood damage, their evacuation behavior and the reasons for their behavior

- Q1; Suffered from flood damage or not
- Q2; The kind of flood damage (only for respondents who suffered from flood damage)
- Q3; Evacuated or not
- Q4; Place that evacuated (only for respondents who evacuated)
- Q5; Reasons for evacuating (only for respondents who evacuated)
- Q6; Did not evacuate or could not (only for respondents who did not evacuate)
- Q7; Reasons that did not evacuate (only for respondents who did not evacuate)
- Q8; Reasons that could not evacuate (only for respondents who could not evacuate)

SECTION 3: The expectation on future flood disaster mitigation measures based on the reason of evacuation behavior

Q1; Awareness for flood disaster mitigation measures

- The outline of result of questionnaire

Respondents in Luang Namtha, Lao PDR were from almost every generation distributed closely. However most of the respondents are males who are the heads of the family. The families with 4 to 6 members accounted for almost half. About the occupation, the farmers accounted for 83%. Regarding the period of living, over 30 years and from 10 to 19 years were in the majority. There were few people with living period from 20 to 29 years. As for the house structure, wooden house accounted for 85%, a brick or concrete house was around 10%. The most commonly observed house type was high-floored 1-story wooden house. The high-floored (pilotis) type house, even through it is 1-story, has a function of 2-story-house during floods. About the flood experience, the memory of residents almost corresponded with the actual numbers of flood occurrence. The residents who had evacuation experience were around half of all respondents. On the evacuation behavior in 2006 flood, the rate of the residents who evacuated was 52%, the residents who did not evacuate accounted for 48%. Among the residents who did not evacuate, 57% of them did not evacuate consciously, 38% of them answered that they could not evacuate due to some kind of obstacles.

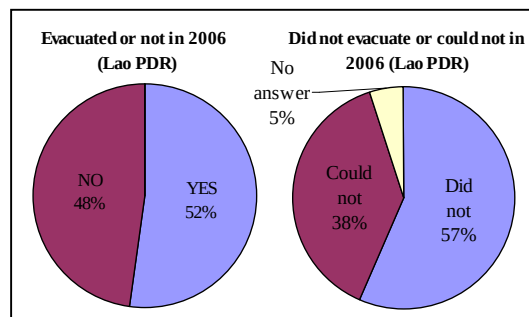


Fig. 2 The Ratio of evacuation behavior in 2006flood, Luang Namtha, Lao PDR

Respondents in Phnom Penh, Cambodia were from almost every generation distributed closely. On the other hand, the numbers of female respondents exceeded that of male. Regarding the number of people in a family, the families with 4 to 7 members accounted for almost half. About the occupation, manufacturing industry and service industry had the highest rates among various kinds of occupation. Regarding the period of living, 10 to 29 years accounted for nearly 80%. As for the house type, 96% of the houses in the area were made by wood. Only 2% were made by bricks or concrete. Most of 1-story houses were high-floored ones like in Lao PDR. About the flood experience, 70% of the respondents experienced only one flood. This flood occurred in 2000. Although the inundation has occurred almost every year, they recognize only the flood in 2000, one of the largest floods with flood disaster. Furthermore some of the respondents who have actually experienced flood while 2000 answered as "Never experiences". It indicates that flood was not recognized as "flood disaster". About the evacuation experience, the respondent with an evacuation experience was 38%. About evacuation behavior in 2000 flood, 37% of respondents evacuated and 63% did not evacuate. All the respondents who answered "did not evacuate" did not evacuate consciously. There was no respondent who could not evacuate by some obstacles, even though they wanted to evacuate.

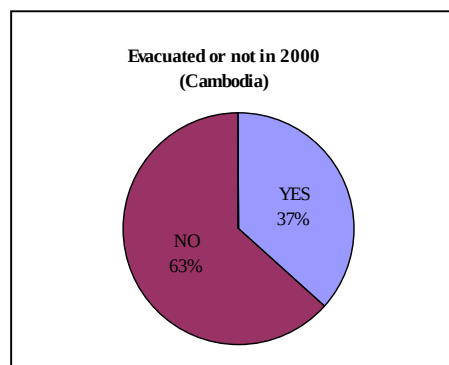


Fig. 3 The ratio of evacuation behavior in 2000 flood, Phnom Penh, Cambodia

Interview survey

In Luang Namtha, Lao PDR, interviewing the chief of the village was carried out. Its main contents were;

- (1) The scale of the village
- (2) The past flood damage

- (3) The flood damage in 2006
- (4) Warning issued or not
- (5) Villagers evacuated or not in flood time
- (6) Current flood disaster mitigation measures.

The interview survey in Phnom Penh, Cambodia was carried out with questionnaire survey. The situation of the flood and awareness for the flood disaster was confirmed by directly talking to the residents.

Investigation of flood situation

In both survey areas, Lao PDR and Cambodia, investigation of the flood situation at survey points in each village gave some information on inundation area and inundation depth. The inundated area maps were drawn according to such information. Location of houses of the respondents and that of the evacuation site are also drawn in this inundated area map. From the map, damage situation of all respondents at the flood time can be known. It could be classified by (1) inundation depth, (2) extent of inundation (above/below floor level), (3) the distance to river and (4) the distance to an evacuation site from houses. Resident awareness for flood disaster from various viewpoints can be analyzed.

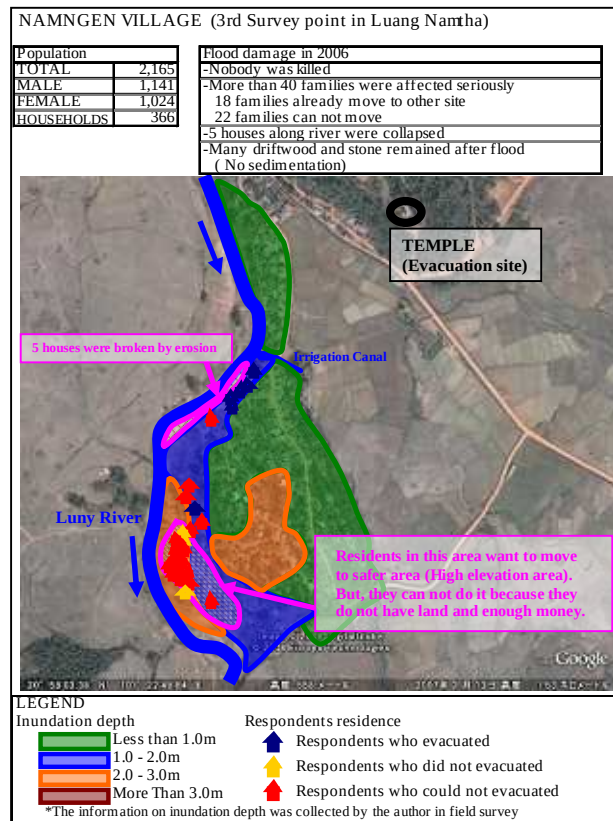


Fig. 4 The inundated area map of 3rd village in Luang Namtha, Lao PDR

RESULTS OF SURVEY

It was the appropriate to use the statistical data to identify the expected reasons objectively. Therefore, the result of questionnaire survey to residents was mainly considered to identify the expected reasons, the result of interview to chief of villages and residents was also considered as the supplemental information.

Table 2 shows the result of identification of reasons. In Lao PDR, main reason was about problem of evacuation site. In Cambodia, many various reasons were identified. In the table, ratio that the reason was chosen in questionnaire is also shown.

Table 2 The result of identification of reasons

The reason that residents did not evacuate		Lao PDR	Cambodia
		Flash Flood	Continental Flood
1-1	False of warnings	× (5%)	○ (92%)
1-2	Inundation would be prevented by facilities	× (9%)	○ (91%)
1-3	No experience of damage	○ (36%)	○ (93%)
1-4	Neighbors did not evacuate	× (13%)	× (79%)
1-5	The evacuation site was too far. The evacuation route was dangerous	○ (36%)	○ (95%)
1-6	Evacuation site had already been crowded	× (5%)	○ (89%)
1-7	Refuge life might be inconvenient and hard	× (9%)	○ (73%)
1-8	Livestock and property might be stolen	× (13%)	○ (94%)
1-9	The level of flood would be a beneficial flood that had been observed annually	-	○ (94%)
The reason that residents could not evacuate		Lao PDR	Cambodia
		Flash Flood	Continental Flood
2-1	Warnings was not issued	× (13%)	-
2-2	Residents could not receive warning	× (0%)	-
2-3	Unknowning where the evacuation site was	○ (53%)	-
2-4	Difficult to take all family member	○ (67%)	-
2-5	Rain and wind was too strong	× (7%)	-
The reason of the damage expansion		Lao PDR	Cambodia
		Flash Flood	Continental Flood
3-1	Vulnerable people were left behind on the dangerous place.	×	×
3-2	Residents suffered from flood, when they went and watched the river and farmland.	×	×
3-3	A lot of poor people lived in dangerous river side.	○	○
3-4	The houses of the poor people was vulnerable to rain and wind	×	○
3-5	Some facilities for flood protection were collapsed and did not work well.	×	×

○:Identified △:New fact is discovered ×:was not identified -:Out of the target

ASSESSMENT OF EVACUATION BEHAVIOR

Some reasons were identified by the results of questionnaire survey and interview survey. However, each resident was exposed to different situations in the flood time. There was some difference in awareness and behavior among villagers. Evacuation behavior was also controlled by some conditions.

Therefore, evacuation behavior of residents was assessed by 4 conditions, (1) Inundation depth, (2) Inundation above/below the floor level, (3) The distance to river from houses, and (4) The distance to the evacuation site from houses.

Among these conditions, “(4) the distance to the evacuation site from houses” has a relation with residents’ evacuation behavior. Fig. 5 shows the ratio of evacuation to the evacuation site classified by distance to the evacuation site. The evacuation rate sharply lowers at the distance of 800m or more. Most of the residents with distance up to 800m went to the evacuation site.

All residents in more than 800m did not go to the evacuation site.

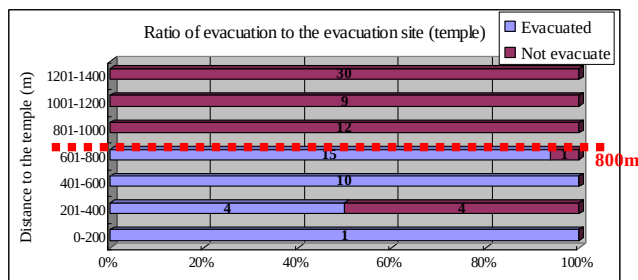


Fig. 5 The ratio of evacuation to the evacuation site classified by distance to the evacuation site

CONCLUSION

Some expected reasons were identified, and identified reasons in two countries were classified into common reasons and those peculiar to each country. Based on these results, conclusion is shown as below.

- i. As common reason in both countries, Lao PDR and Cambodia, “No experiences of flood damage”, “Evacuation site was too far” and “Evacuation route was dangerous” are identified as a reason for not evacuating.
- ii. Main reasons in Lao PDR are problems of evacuation site. On the other hand, main reasons in Cambodia are matters of refuge life and residents’ underestimation of flood occurrence and its scale as well as the problems of evacuation site.
- iii. According to the result of assessment of evacuation behavior, it is clear that upper limit of distance from the residents’ house to the evacuation site is 800m. Generally, 800m distance seems to be a psychological border whether people intend to walk or not. For example, in Japan, price of condominium decreases very much when its distance from train station becomes over 800m (Sakairi Sangyo Corporation, Ltd). Hence from this study, 800m is suggested as the standard of the distance to an evacuation site from houses.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to Professor Kuniyoshi Takeuchi, Director of ICHARM, PWRI, for his detailed comment, valuable suggestion and constant support.

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IMPACT ASSESSMENT OF ROAD CONSTRUCTION ON THE FLOOD INUNDATION IN DHAKA, BANGLADESH

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ABSTRACT

Dhaka, the capital and the most populated city of Bangladesh, is now one of the largest cities with high populated density in the world. Dhaka is surrounded by some satellite cities and the urban growth may cause several effects upon the environment. Increase of inundation area is one of the most serious problems in Dhaka. The aim of this study is to evaluate a future urban development from the view point of flood inundation. 2D model has been selected as simulation model and verification has successfully done by adding rainfall and evaporation values. To confirm the future development, an interview with the government official of Bangladesh who is responsible for the urban development was conducted. It is clear from the interview that the main factor of the urban growth is the road and highway construction. Therefore, Strategic Transportation Plan (STP) has been selected as the future scenario for the simulations. The simulation in the future scenario is conducted by inputting the location of roads and highways. The result shows that the inundation condition will be changed after construction of the new road and highway. To evaluate the situation from the view point of residents, the interview was conducted to 10 people. According to the result of the interview, the residents in those areas are damaged by flood every year and they have to evacuate for the period of 3 months. It causes damage to their economic and daily life and if the duration becomes longer, they will suffer from worse situations. However, the result of the simulation shows that depth of inundation will keep flow capacity if outlet (bridges) is added to the new road with 4500m interval. It should be noted that this evaluation is made on the condition the land-filling works is not done in the wetland. Therefore if this condition is changed, the situation will change worse accordingly. The government should make the strict guideline for the future land filling and development.

Keywords: Inundation simulation, Interview, Road construction

INTRODUCTION

Dhaka, one of the most populated cities in the world, is facing rapid urban development. The urban growth may cause several effects to the environment and the increase of flood damage is one of the most serious problems in Dhaka. Some government officers of Bangladesh are seriously worried about its effect on the drainage capacity. It is necessary to evaluate future development which may cause adverse effect to the changes of

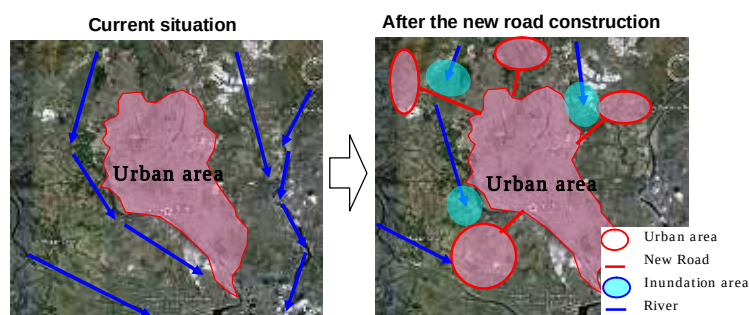


Fig. 1 The problem in the future

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drainage capacity (Fig. 1). The effect on the capacity of flood protection is one of the important issues which government has to consider. There is a possibility that future development will cause drainage congestion and reduce drainage capacity during a flood. The aim of this study is to evaluate the road construction, which is one of the important factors of urban development from the view point of flood inundation.

METHODOLOGY

This study has three parts of analysis, which are simulation, interview to the government and interview to the residents (field survey). Firstly, the suitable model for inundation simulation in Dhaka is selected. Secondly, interview with the government officials who are responsible for urban development in Dhaka is conducted to decide the urban development scenario. Thirdly, interviews have conducted with the residents who have experience of flood. Finally, the simulation in future urban development scenario is conducted.

Outline of Interview with the residents

Interview with residents was conducted to see the situation of the flood and their factor of the problems. By questionnaire, it is impossible to listen to their detailed information. On the interview, the detailed information and situation can be known through face-to-face talk.

Outline of Interview with government officials

Interview with government officials was conducted to select the future urban plan. The government officials who have a responsibility for the urban development and town planning (RAJUK, Bangladesh Water Development Board, Road, Highway Department and Dhaka City Office) were selected for the interviewees.

Outline of simulation model

In order to derive the general momentum equation for fluid flow in hydrologic term, control volume approach along with Newton's second law was used. Here, M and N are discharge fluxes ($M=uh$, $N=vh$) u is the x-direction flow velocity, v is the y direction flow velocity, h is water depth H is the water level and τ is a share stress.

$$\frac{\partial M}{\partial t} + \frac{\partial}{\partial x} uM + \frac{\partial}{\partial y} vM = -gh \frac{\partial H}{\partial x} - \frac{\tau_b}{\rho} \dots\dots\dots (X\text{-direction momentum equation})$$

$$\frac{\partial N}{\partial t} + \frac{\partial}{\partial x} uN + \frac{\partial}{\partial y} vN = -gh \frac{\partial H}{\partial y} - \frac{\tau_b}{\rho} \dots\dots\dots (Y\text{-direction momentum equation})$$

The continuity equation shows control volume during the small time interval.

$$\frac{\partial h}{\partial t} + \frac{\partial M}{\partial x} + \frac{\partial N}{\partial y} = 0 \dots\dots\dots (\text{Continue equation})$$

Difference equations

Difference equation was developed from basic equations. These equations are based on the calculation grid shown in Fig. 2. In this procedure:

- Discharge fluxes M and N at time n+2 are calculated from water depth and level at time n+1 and flux at time n.

- Water depth at time $n+3$ is calculated from fluxes at time $n+2$
- Momentum equations at x-direction are as follows:

$$\frac{M_{i,j+2}^{n+2} - M_{i,j+2}^n}{2\Delta t} + \text{convx}(x) + \text{convx}(y) = -g \frac{(h_{i-1/2,j+1/2}^{n+1} + h_{i+1/2,j+1/2}^{n+1})(H_{i+1/2,j+1/2}^{n+1} - H_{i-1/2,j+1/2}^{n+1})}{2\Delta x}$$

$$- g n_{i,j+1/2}^2 \frac{(M_{i,j+1/2}^n + M_{i,j+3/2}^{n+2}) \sqrt{(u_{i,j+1/2}^n)^2 + (v_{i,j+1/2}^n)^2}}{2((h_{i-1/2,j+1/2}^{n+1} + h_{i+1/2,j+1/2}^{n+1})/2)^{4/3}}$$

Momentum equations at y-direction are as follows:

$$\frac{N_{i,j+2}^{n+2} - N_{i,j+2}^n}{2\Delta t} + \text{convy}(x) + \text{convy}(y) = -g \frac{(h_{i+1/2,j-1/2}^{n+1} + h_{i+1/2,j+1/2}^{n+1})(H_{i+1/2,j-1/2}^{n+1} - H_{i+1/2,j+1/2}^{n+1})}{2\Delta y}$$

$$- g n_{i,j+1/2}^2 \frac{(N_{i,j+1/2}^n + N_{i,j+3/2}^{n+2}) \sqrt{(u_{i,j+1/2}^n)^2 + (v_{i,j+1/2}^n)^2}}{2((h_{i+1/2,j-1/2}^{n+1} + h_{i+1/2,j+1/2}^{n+1})/2)^{4/3}}$$

Continue equation are as follows:

$$\frac{h_{i+t/2,j+j/2}^{n+3} - h_{i+t/2,j-j/2}^{n+3}}{2\Delta t} + \frac{M_{t,t+2}^{n+2} + M_{t,t+2}^n}{\Delta x} + \frac{N_{t,t+2}^{n+2} + N_{t,t+2}^n}{\Delta y} = 0$$

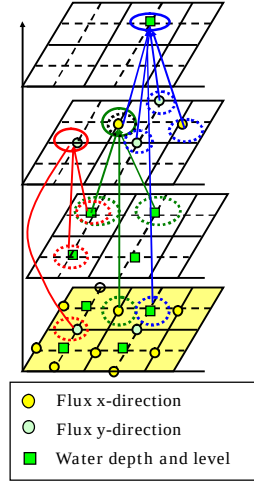


Fig. 2 Outline of interviewees

Boundary conditions

The boundary conditions are shown in Table 1. Which is external boundary condition and internal boundary conditions are applied into the model.

Table 1 Outline of interviewees

	Boundary condition	Flux
External boundary conditions	Levees and mountain adjacent to flooded area:	M or N= 0
	Levees breach point and discharge pump stations:	Discharge flux was given
	Discharge flux was given.	Discharge flux was given
Internal boundary conditions	W.L is higher than the water level surrendering grids.	M or N= 0
	Discharge flux of a grid with a water depth 0.005m or less.	M or N= 0
	Water depth calculated to be negative.	M or N= 0
	In case of overtopping(Fig.2.5), the equations the M and N is calculated as follows:	$M_{or} N = \mu h_1 \sqrt{2gh_1} \frac{h_{1,2} - \frac{2}{3}}{h_1}$ $M_{or} N = \mu h_1 \sqrt{2g(h_1 - h_2)} \frac{h_{1,2} - \frac{2}{3}}{h_1}$
	In case of drop flow	$M_{or} N = Ch \sqrt{gh}$

Topography and discharge data

The discharge of Dhaleswari river is assumed as twice as Kariganga which is tributary of Dhaleswari river. Discharge of Balu river is assumed as half of the discharge in Derma-Balu. Discharge of Meghna river is assumed as 3000m³/s in rainy season and 700m³/s in dry season (Fig. 3).

Topography data was selected from HydroShedS (<http://hydrosheds.cr.usgs.gov/>). The grid size is 300m for x and y directions. By the discussing with government officer in Bangladesh, the Manning's roughness coefficient was decided as 0.030 in flood plain and 0.020 in river bed (Fig. 4).

Comparison with the inundation map

In this section, the comparison of the simulation result and observed data on 24 August, 2004 was done. The observed data is taken from Flood Forecasting and Warning Center (FFWC) in Dhaka.

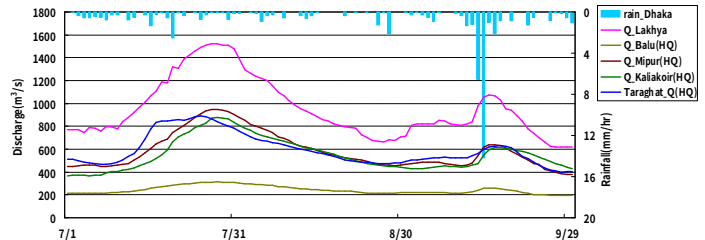


Fig. 3 Discharge and rainfall

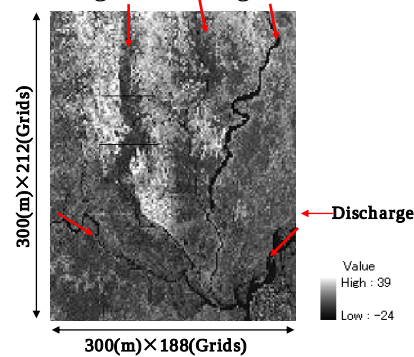


Fig. 4 Topography data

The comparison is shown in Fig. 5. The yellow part of the map shows protected areas (surrounded by embankments). The simulation results are fairly good. Especially, the north eastern and western part of Greater Dhaka (in the red circle) shows almost same water depth.

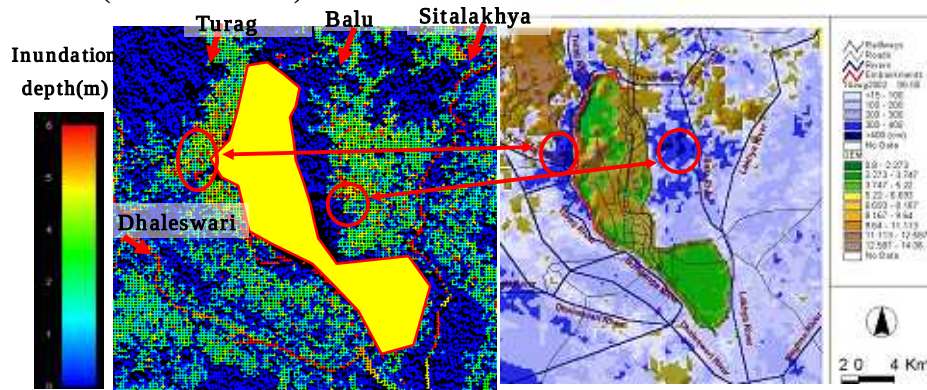


Fig. 5 Comparison with the inundation map

Comparison of simulation result with the water level in Mill Barak

The comparison of the observed data and simulation data at Mill Barak is shown in Fig. 6. The simulated water level of the end of July is little bit lower than that of observed data.

The reasons for these differences are:

- Discharge from the pumping systems has affected to water level.
- Topography data which was selected from SRTM and its grid size is about 300m.

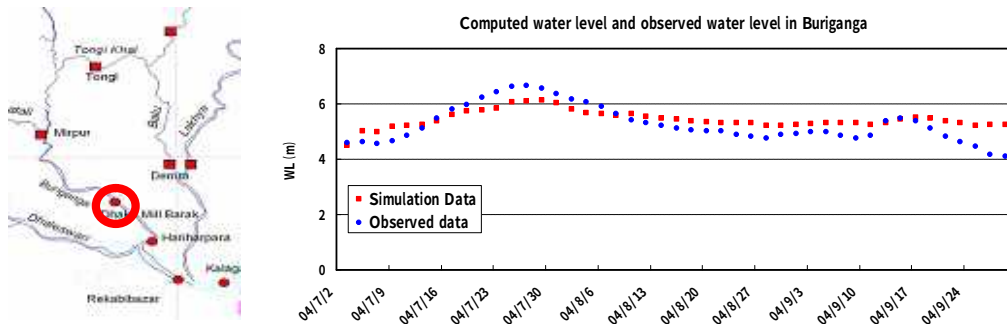


Fig. 6 Comparison with the inundation map

RESULTS AND DISCUSSION

Interview with government officials

According to interview with government officers, Dhaka is rapidly increasing their urban area by land-filling on the wetland which is located outside the embankment. If the roads and bridges connecting suburban area with Dhaka were constructed, a lot of land filling will be done along the road. Therefore, road is one of the main factors in urban growth and there is a possibility that these road will be stop the water flow during the flood. In Dhaka, there are several urban and transportation plans which have been published by the government and ADB. The main plans are Dhaka structure plan, Detail Area Plan and Strategic Transportation Plan. DMDP was published more than 10 years ago and DAP is still under construction. STP describes comprehensive urban plan which considers the future urban structure.

Interview with residents

By pre-interview on 6 June, the interview methods for the field survey was selected. The problems of questionnaires are as follows:

- It is difficult for the residents to choose one reason or factor for the flood damage.
- Some people cannot read questionnaires.

The interview was held to identify the resident's opinions. The number of interviewees was 10 people (Table 2). On the interview, the detailed information and situation can be known through face-to-face talk.

- Many people answered that they realize that flood is coming when the water level rises up to 3ft.
 - All the residents answered that flood duration is maximum 4month.
 - Houses and crops are damaged by the flood every year and it takes several months to recover.
- According to the interview, residents realize that flood is coming when the water level rises up 3ft. This can be the criteria of the inundation area in the simulations

Table 2 Interview results

	Interviewee	Sex/ Age	The water depth when they realize the flood	Situation during flood
1-1		-	3 feet	Too long evacuation time and there were fighting because of flood
1-2		Male/23	2 to 3 feet	I didn't find any problem. People are very kind
1-3		Female	3 feet	I didn't find any problem. People are very kind
1-4		Male/40	Neighbor houses were inundated and I realize that flood comes (about 3ft)	It was tough because of the duration, but people were helping each other
1-5		Male/30	3feet	-
2-1		Male/50	When the water level rise up to my shoulder (4ft)	-
2-4		Female/40	3feet	People were cooperative
2-2		Male/70	Water level suddenly goes up and I was confused	-
2-3		Male/50	When the water level rise up to ground floor (5ft)	-
2-5		Male/50	3feet	-

Simulation with/without Highway

Future inundation area is calculated by 2D model. Discharge, Manning's roughness coefficient, topography and duration are the same as verification. The new highways, which is inputted into 2D model is based on Strategic Transportation Plan in 2024. Inside of the Greater Dhaka will be protected by the embankment. Therefore, the new highway outside of Greater Dhaka was considered. The planned highways described in STP connect Greater Dhaka to suburban area. According to RHD officer, the bridge is constructed only on the river courses.

Simulation results in 30 July, 2004 (the highest water level in July, August and September in 2004) is shown in Fig. 7. The blue circle shows the area where inundation will be increased and yellow circle shows the area where inundation area will be reduced. Inundation area which water depth more than 1m water depth will decrease after the completion of new highway. It became clear that the current highway construction could change the flood situation. In case of using highway as embankment, detail studies are required to identify the inundation area and strict guideline.

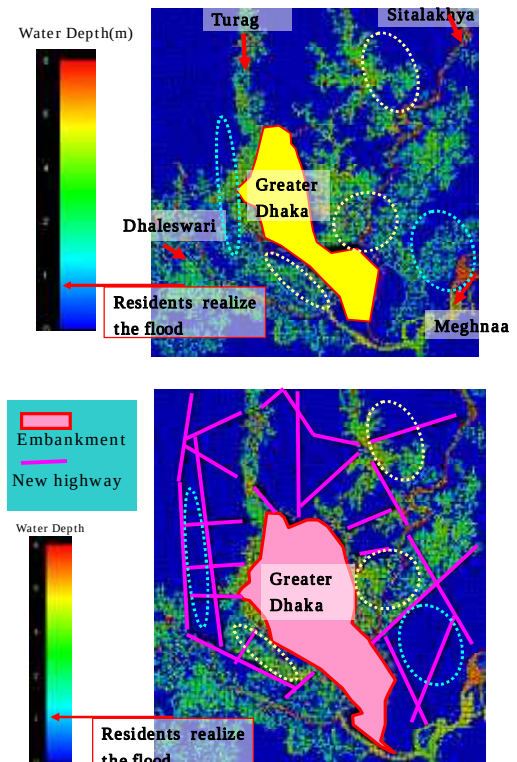


Fig. 7 Simulation with/without highway

Simulation with/without Bridge

Increase the culvert is one option of mitigation the damage. Outlets are used to discharge inland flowed water to outer rivers. It may be used to allow water to pass underneath a road, railway, or embankment.

In this section, simulations with and without outlet were conducted. The interval of the culvert is assumed as approximate 4500m and length of outlet are 400m. The culvert is proposed into the all the highway except for the road inside of the protected area. The discharge and Manning's roughness coefficient are considered to be same as the simulations as verification (Fig. 8).

The blue circle shows the changes of inundation conditions. By constructing bridges, the inundation area will be reduced in up stream side of highway.

By constructing highway without bridge, inundation area in down stream side of highway will be reduced and inundation area in up stream side of highway will be increased. In case of constructing highway without bridges, it is necessary to prepare the guideline to control the land-use in up stream side of highway.

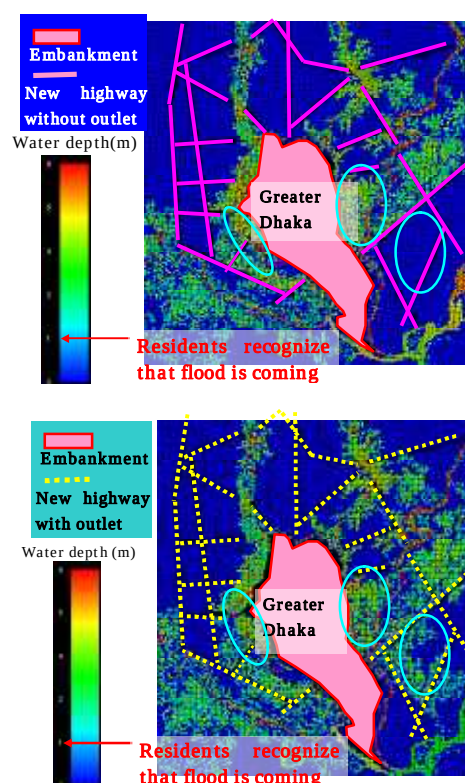


Fig. 8 Simulation with/without bridge

CONCLUSION

By constructing highway without bridge, inundation area in down stream side of highway will be reduced and inundation area in up stream side of highway will be increased. In case of constructing highway without bridges, it is necessary to prepare the guideline to control the land-use in up stream side of highway. By constructing bridge in 4500 m interval, inundation area in up stream side of the highway will not be increased and inundation area in down stream side of highway will not be reduced.

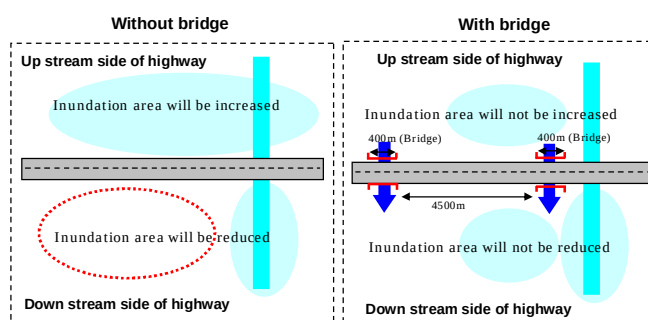


Fig. 9 Implication of countermeasure

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A NUMERICAL STUDY ON THE OPEN CHANNEL NETWORK IN WUXI CITY

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ABSTRACT

Numerical simulations were conducted to estimate the performance of a drainage system of Wuxi City in China which is now under construction to realize the full plan of flood control system in 2009. The city has a complicated canal network which has served for water transportation from ancient times. Recently, however, the flood water coming through the canal system causes inundation in the city center. Accordingly, the system is separated from the ambient river system with water gates, which are equipped with pump stations of large capacity to discharge rain water from the city center to the outside.

In this study, a numerical simulation model to solve a networked open channel flow developed by Tokyo Institute of Technology was used to estimate the hydraulic characteristics of the channel network in Wuxi City. After constructing a model of channel network for calculation being based on a map of waterways and some related data, a numerical simulation is conducted under a condition of full pump operation without rainfall in order to estimate the total drainage capacity of the system. Then, the system capability under intense rainfalls was examined numerically for some realistic and possible conditions.

Major findings are as follows: (1) The present system can prevent inundation under the rainfall condition which caused a large flood disaster in Wuxi City in 1991. (2) The pumps at three eastside stations can be stopped even with the rainfall condition in 1991 in order to prevent inundation in the east suburbs where river channel capacity is not enough yet. (3) If the peak intensity of rainfall is two times larger than that in 1991, which might be caused by a change of atmospheric system depending on the global warming, local inundation might be generated. (4) When the conditions of (2) and (3) occur at a same time, it is necessary to discharge the water in networked channels at least one hour in advance being based on weather forecast.

INTRODUCTION

After a large flood in 1991, Wuxi City made a drastic plan of flood control, in which water gates can separate the canal network in the central area from ambient river system in rainy season and improved dikes raise the High Water Level the open channels in the city. These facilities will increase the safety level against flood waters coming into the city, but it will become difficult to discharge the rain water in the city to the outside. Therefore, pump stations of large capacity are also under construction at seven major water gates. The whole construction project will be finished in 2009.

Because any intense rainfall has not occurred after the construction started, the performance of the system has not been tested even partially. On the other hand, because the open channel network in Wuxi City, having more than 200 channel segments, is very complicated, it is difficult to examine the networked flow analytically, and only numerical simulation is considered to be a possible and effective method for this purpose. However, numerical simulation for the whole channel network has not been conducted yet because Wuxi City does not have any skills for it.

In this study, considering the situation mentioned above, the performance of the drainage system is examined by using a numerical simulation model recently developed by Tokyo Institute of Technology.

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STUDY AREA

Wuxi City is located on a flat low land at the south side of the lower Changjiang as shown in Fig. 1. The land has been cultivated for thousands of years because of the productive soil transported by the Changjiang. It is still one of the most important areas in China for its agricultural and economic development. Wuxi City has a complicated canal system by connecting the rivers and lakes since the ancient times as shown in Fig. 2. It has been utilized not only for water transportation but also as channels for flood water drainage to the outside of cities and as water amenity places for citizens.

In recent years, however, the potential of flood disaster is rising with the increase of rain run-off because of the modern development of the area. Flood water coming from the outside through the canal system causes larger flood damage in Wuxi City than before. Therefore, Wuxi City is now separating the canals from the outside river system by water gates. But, it decreases the drainage capacity to discharge the rain water to the outside of the city. In order to solve the problems, pump stations of large capacity are under construction at seven major water gates, the location of which are marked in Fig. 2. Construction of the facilities is scheduled to realize the full plan of flood prevention works in 2009. The important values of water surface level for the water management in the plan are listed in Table 1

Table 1 Important water level

Normal Water Level (NWL)	3.3 meter a.s.l.
Warning Water Level (WWL)	3.6 meter a.s.l.
Inundation Water Level (IWL)	5.0 meter a.s.l.



Fig. 1: Location of Wuxi City



Fig. 2: Open channel network in Wuxi City

HYDRAULIC SIMULATION MODEL

The hydraulic simulation model adopted here (Tokyo Tech Model) is to solve 1-D equations of open channel flows for channel segments in a network by explicit finite difference scheme on staggered grids. Basic equations are the continuity equation and the momentum equation which are written as follows:

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q \quad (1), \quad \frac{\partial Q}{\partial t} + \frac{\partial (UQ)}{\partial x} = -gA \frac{\partial H}{\partial x} - \frac{\tau}{\rho} P \quad (2),$$

where t is time, x is distance along each channel, A is cross section, Q is flow rate, q is the side inflow per unit length of channel, U is mean velocity, g is gravity acceleration, H is water surface level, ρ is density of water and P is wetted perimeter, and τ is bottom shear stress which is expressed by Eq. (3), where n is so-called Manning's coefficient and h is water depth. At each channel junction, the volume conservation can be expressed by Eq. (4), where A_j is an area of junction which is assumed as a square of mean width of joining channels.

$$\frac{\tau}{\rho} = fU|U| = \frac{gn^2}{h^{1/3}}U|U| \quad (3) \quad A_j \frac{\partial h}{\partial t} = \sum_i Q_i \quad (4)$$

Time integrals of eqs. (1) and (2) are calculated by finite difference formulation written as follows:

$$\frac{A_j^{K+1} - A_j^K}{\Delta t} + \frac{Q_{I-1}^{K+1} - Q_{I-1}^K}{\Delta x} = q_j^K \quad (5)$$

$$\frac{Q_I^{K+1} - Q_I^K}{\Delta t} + \frac{U_{J+1}^K Q_{I+I_s}^K - U_J^K Q_{I-1+I_s}^K}{\Delta x} = -gA_I^K \frac{H_{J+1}^K - H_J^K}{\Delta x} - \frac{\tau_I^K}{\rho} P \quad (6)$$

where superscripts and subscripts are time steps and grid numbers respectively as shown in Fig. 3.

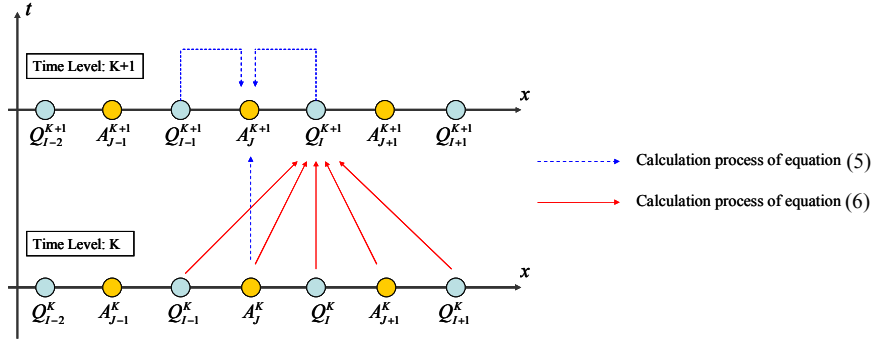


Fig. 3: Algorithm for time integral

CHANNEL NETWORK MODEL

The channel network in Wuxi City is very complicated as was shown in Fig. 2. In addition, dimensions of many small channels are not measured yet. Therefore, the model channel network for calculation was constructed by using the latest map, pictures and authors personal knowledge about the appearance of channels as well as some numerical data available for comparatively large channels. Channel cross sections for calculation are assumed to be rectangular with a flat bottom which elevation is 0.0 a.s.l.. It is a rough assumption and should be checked in the future. Fig. 4 shows the result which is simplified from the prototype shown in Fig.3.

In a usual river planning, Manning's coefficient, n , is estimated from field data obtained in a quasi steady-uniform condition. In the case of Wuxi channel network, however, those data do not exist because each channel segment is too short for such a condition to appear. Accordingly, the values of n were assumed being based on a literature (Ven Te Chow, 1959) and author's personal knowledge about the appearance of channels in the city. Values of n adopted in this study are listed in Table 2, where two kinds of values are assumed for the group of smallest channels. It is because the roughness coefficient especially of small channels can be changed by practical conditions such as block of flow by solid waste.

Table 2 Manning's coefficient

	$B \geq 40$	$40 > B \geq 20$	$B < 20$
C-1	0.02	0.04	0.06
C-2	0.02	0.04	0.1

B : channel width (m)

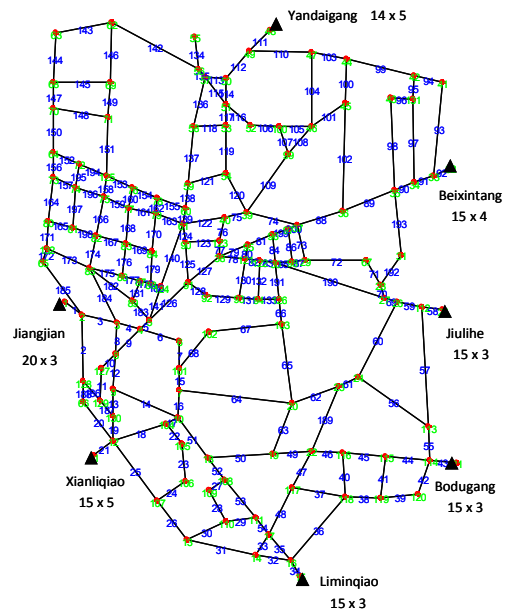


Fig.4: Channel network model

ESTIMATION OF DRAINAGE CAPACITY

The drainage capacity of the system was examined by checking the total flow resistance under the condition of full pump operation without rainfall. Water in the channel network was still at the level of 4.5 meters initially. Pump operation rule was assumed being based on the flood control plan: When the water level at each pump station is higher than WWL, all pumps are run. When the water level is between WWL and NWL, the total discharge is set to be 2/3 of the total capacity of the station. However, because each pump can take only two conditions, ON and OFF, the total discharge is set to close to the 2/3 at stations where the number of pumps is not in multiples of 3. When the water level becomes lower than NWL, all pumps at the station are stopped.

Fig. 5 shows the variations of water level at four points in the network, which are selected from some channel segments where the water levels are comparatively high or low. The location of each point is plotted in a reduced map in the figure. The water surface decreased with a rate of 0.5 meter/hour in average when pumps are full operated. The difference among the water levels is 0.2 meter at the maximum. This fact suggests that the flow resistance is not a very big problem. After stopping pump operation, oscillation of about 10 cm appeared but ceased in about two hours. This kind of motion is considered to be caused by propagation of waves (surging) in the channel network.

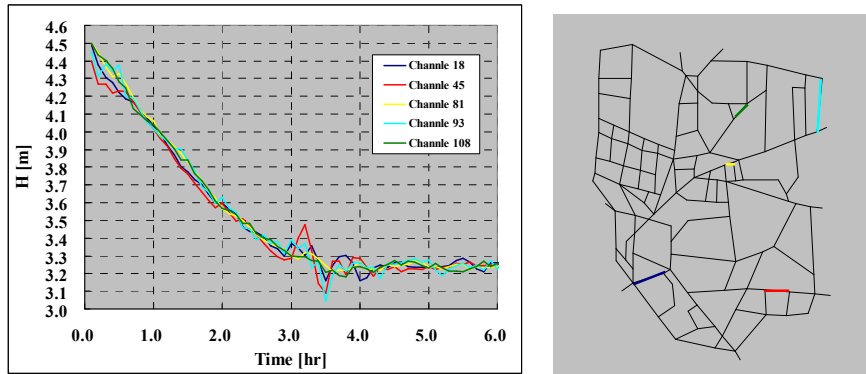


Fig. 5: Water surface decline under full pump operation

SYSTEM CAPABILITY UNDER THE INTENSE RAINFALL OBSERVED IN 1991

Fig. 6 shows the rainfall which caused a large flood disaster in Wuxi City in 1991. It is the largest rainfall of 24-hour in these 60 years, and the safety of the city center from the rainfall is required in the flood control project. Because there was no water gate and pump station in 1991, this calculation is the first attempt to estimate the capability of the present system under the recorded maximum rainfall.

Fig. 7 shows the water levels at four places as shown in a reduced map in the figure. They go up and down with the change of rainfall intensity with small difference from one another except in the time of surging. The water surface rises above WWL frequently, but the highest is 3.95 m. This fact means that the present

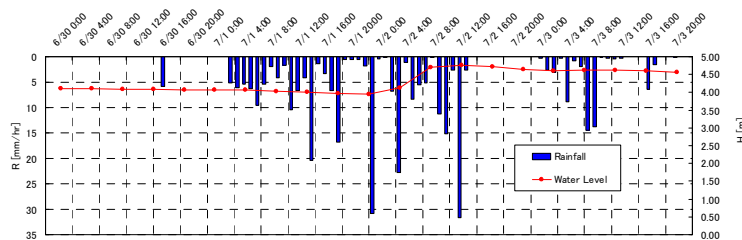


Fig. 6: Rainfall observed in 1991 (Nanmen meteorological station)

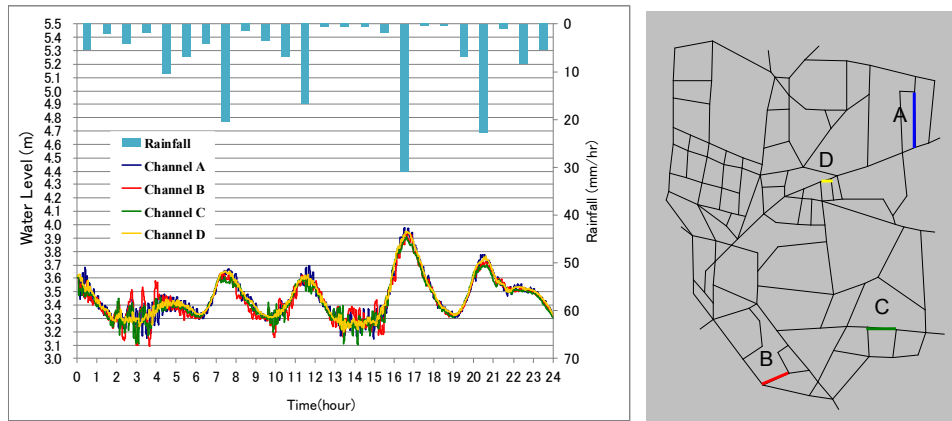


Fig. 7: Water level under the rainfall observed in 1991

total pump capacity is large enough to prevent the inundation disaster which occurred in 1991. By the way, even with larger roughness for small channels listed in Table 2, the result was almost the same as Fig. 7.

SYSTEM CAPABILITY UNDER SOME POSSIBLE CONDITIONS

Numerical simulations were conducted further, considering two kinds of uncertainty in practical situations. One is a local condition of eastside suburbs. River channels in the area are still under improvement and inundation frequently occurs. Because of the practical reason, there is a possibility that three pump stations at the east side of the city center cannot be operated when inundation occurs there earlier than in the city center. Therefore, the system capability without the operation of the three pump stations was examined. The calculation result showed that the city center is still safe from inundation under the condition, though the data are not shown here because of a limitation of space.

The other is a meteorological uncertainty. As mentioned before, the 24-hour rainfall observed in 1991 was the largest in these 60 years. But, more intense rainfall might occur because of a change of atmospheric system caused by the global warming. Therefore, a simulation was carried out for a rainfall in which the peak intensity in one hour was two times larger than that in 1991. The maximum rainfall intensity of the case was 60 mm/hour, which is not very unusual all over the world. Fig.8 shows the results. The water level exceeds IWL a little bit, which means that inundation might be generated locally.

Fig. 9 shows the calculation result for a combination of the two conditions mentioned above. The water surface keeps the level higher than IWL for a long time, and the maximum is 5.4 m. The rate of water surface rising before the first peak is about 2.0 meter/hour. On the other hand, the rate of water surface decreasing under the full pump operation is 0.5 meter/hour, as was shown in Figure 5. This fact means that

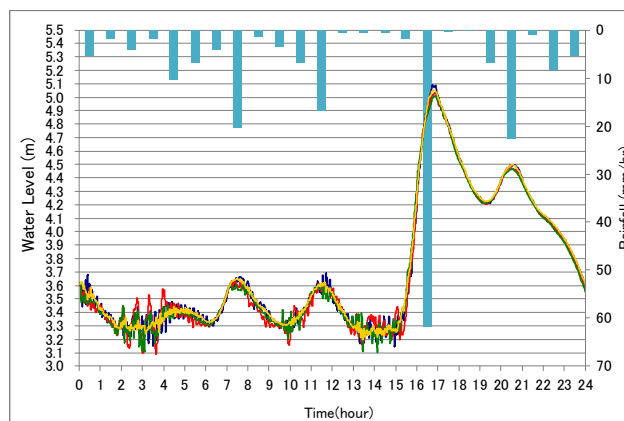


Fig. 8: Water level under the rainfall which peak intensity is two times larger than the rainfall observed in 1991

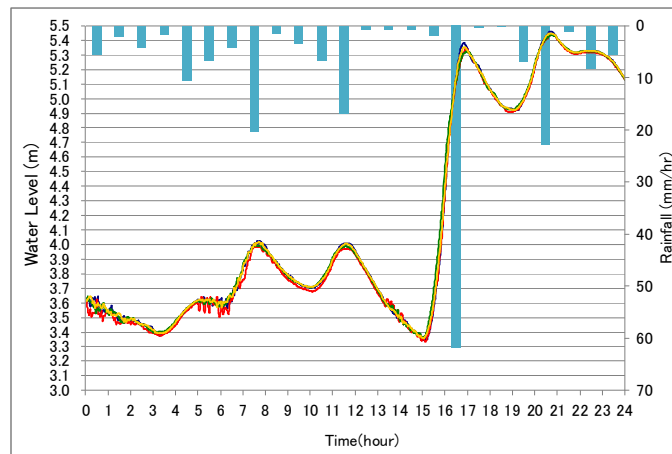


Fig. 9: Water level under the rainfall observed in 1991

pump operation at least one hour in advance is necessary when a rainfall of the order of 60 mm/hour is forecasted.

CONCLUSIONS

Major findings in this study are as follows:

- 1) Under the full pump operation without rainfall, the water surface falls almost uniformly in the channel network with a rate of 0.5 meter/hour. Spatial difference of the water level is less than 20 cm.
- 2) The drainage system of Wuxi City, which will be completed in 2009, can prevent inundation under the rainfall condition which caused a large flood disaster in 1991.
- 3) The pumps at three eastside water gates can be stopped even with the rainfall condition in 1991 in order to prevent inundation in the east suburbs where river channel capacity is not enough yet.
- 4) If the peak intensity of rainfall is two times larger than that in 1991, which might be caused by a change of atmospheric system depending on the global warming, local inundation might be generated.
- 5) When the conditions of 3) and 4) occur at a same time, it is necessary to discharge the water in networked channels at least one hour in advance being based on weather forecast.

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