INCEDE: At the End of a Decade
- Summarizing its 8-year activities -

K. Sudo[1], S. Herath[2], K. Meguro[3] and D. Dutta[4]

Abstract

United Nations (UN) declared 1990-2000 as the International Decade for Natural Disaster Reduction (IDNDR). The International Center for Disaster-Mitigation Engineering (INCEDE) was established in April 1991, within a year after the UN declaration, as a national contribution of Japan towards UN initiative of natural disaster reduction. The center was established in a university environment at Institute of Industrial Science (IIS) of the University of Tokyo with the objectives of doing fundamental research on various aspects of disaster reduction and tackling problems in disaster mitigation through synthesizing information and methodologies from different fields, mainly from earthquake, water induced disasters, remote sensing and GIS fields. Now, IDNDR is almost at the end of its official period, less than a year to go. Reaching the final stage of this disaster reduction decade, we review overall activities of INCEDE, what had been done so far, how much have been achieved and what will be the goals for the future, through this report. This report summarizes the last 8-year activities of INCEDE and its prospective in the new millenium after the IDNDR.

1. INTRODUCTION

Due to the permanent increase of natural disasters in the last few decades, a resolution of the United Nations (UN) in December 22, 1989 declared the 90's as "The International Decade for Natural Disaster Reduction (IDNDR)". The main goal of the IDNDR was the use of specialists and technical equipment to count the losses of human lives, properties and destruction of socio-economic bases, which frequently result from natural catastrophes. Along with many other activities of Japanese Government to support UN initiatives for natural disaster reduction, the International Center for Disaster-Mitigation Engineering (INCEDE) was formed in April 1991 at the Institute of Industrial Science (IIS) of the University of Tokyo, as a national contribution of Japan towards IDNDR for promoting fundamental research on disaster mitigation and information dissemination from an international and university researchers' view point. In general, as a country most vulnerable to various types of natural disaster, importance of disaster mitigation is always realized in Japan. However, Kobe earthquake of 1995 made this realization much stronger among the various levels of society from researchers to decision makers by shattering the general perception that Japan possessed the required technology for disaster mitigation. For INCEDE, it was realized that establishment of the center was timely to carry out fundamental research and increase awareness of public for disaster mitigation issues at national as well as international levels.

1) Ken SUDO, Director, International Center for Disaster-Mitigation Engineering, Institute of Industrial Science, The University of Tokyo, 4-6-1, Komaba, Meguro-ku, Tokyo 153-8505, Japan, http://incede.iis.u-tokyo.ac.jp/
2) Anura Srikantha HERATH, Visiting Professor, ditto.
3) Kimiro MEGURO, Associate Professor, ditto.
4) Dushmanta DUTTA, Research Associate, ditto.

Now, IDNDR has reached almost its final stage, only a year to go before it would officially end. This year, many workshops and meetings are taking place in different continents to evaluate IDNDR activities and achievements and to device strategies for the next decade. Reaching the end of this decade for disaster reduction, we have realized that we need to review our almost a decade long activities. In this report, we summarize various activities of INCEDE during the last 8-year period and possible directions of INCEDE for the post-IDNDR decade.

2. OBJECTIVES OF INCEDE[1)]

Objectives of the INCEDE are to promote fundamental researches for disaster mitigation and information dissemination from an international and university researchers' point of view. INCEDE synthesizes information and methodologies from different fields, mainly from earthquake, water induced disasters, RS/GIS fields, to tackle the problems in disaster mitigation. At present, INCEDE specializes mainly in the disciplines of urban earthquake disaster-mitigation engineering, hydrology/water resources, and RS/GIS.

When the INCEDE was established, the following proposals were presented:

1) Recent changes surrounding a city such as increase population, expansion of the city, and concentration of industries and social capitals in the disaster prone areas, are making the city weak against natural hazards. As for the kinds of disasters, they are shifting from the structural oriented to information or system oriented, with an increase of potential risk of damage to city functions. Fundamental research to reduce the vulnerability to disasters is necessary for minimizing the damage.
2) If a large natural hazard like an earthquake or a flood occurs, damage would be huge and might cover many countries. Without international cooperation, a country struck by such a disaster finds it difficult to respond on its own. This fact highlights the importance of international cooperation in minimizing the effects of a disaster.
3) From these view points, promotion of the fundamental research for developing new technology to make the effects of natural disasters clear and mitigating them becomes very important.
4) For this purpose, we need to establish a research center, which promotes fundamental research as well as develop new technology in order to contribute to international cooperation through joint research with overseas organizations.
5) In addition, establishment of such a center can be Japan's national contribution for the activities of IDNDR.

3. DISASTER MITIGATION RESEACH IN THE UNIVERSITY AND INCEDE

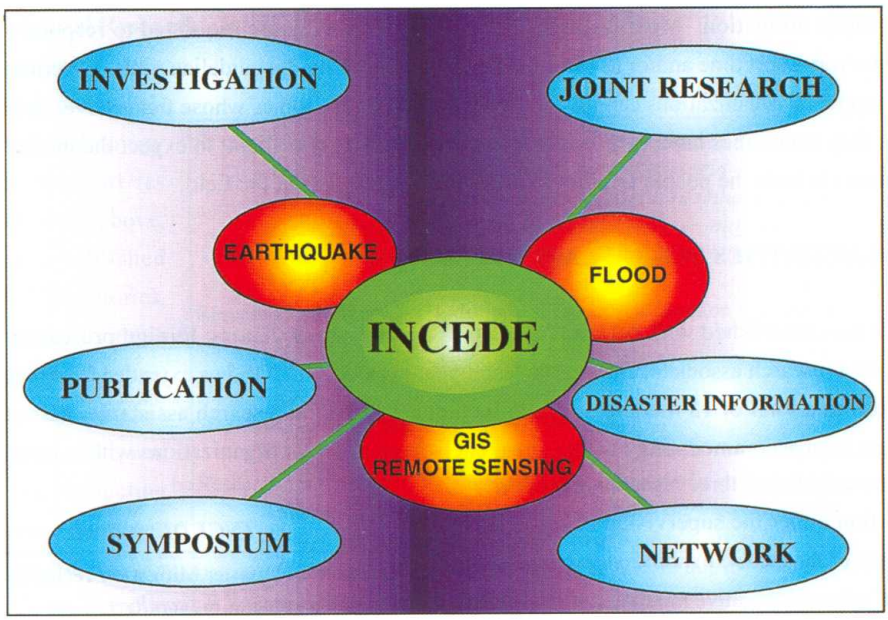
3-1 University Institutes in Disaster Reduction

The special role of the university institutes is the promotion of both fundamental and applied research that should be carried out in a long time span. University institutes have the advantage to continue the research from a neutral position spending a long time. This point is very important in the field of disaster mitigation, as it requires long term research.

Research with results not so valuable in near future but which will be of great value in years to come, and research which is of great importance but no visible solutions or time limitations are also problems which

should be tackled by the university institutes. Applied research by university institutes should be ones whose fields cover several academic societies. The research for standardization of earthquake resistant design code, and returning the results of their fundamental research to the society can be pointed out as examples. Another important role of university researchers may be to act as good public translators of the knowledge on disasters using easy terms.

In addition to these, university has a very important role as an educational organization. Universities are expected to provide human resources and to conduct research. University institutes, therefore, should actively



INCEDE Organization

INCEDE staff together with the Director of IDNDR Secretariat
Dr. Philip Boulle (1st from the left in the front row) during his visit to INCEDE

educate practitioners and officials based on the fact that cooperation between researches and practitioners, and that between institutes and governmental disaster related organizations are very important for disaster mitigation. In addition, university institutes have to play a role as an information dissemination center for international societies.

3-2 Other Institutes in Disaster Reduction

Ministry of Construction, Ministry of Transportation and Science and Technology Agency also have institutes for disaster mitigation. Most institutes listed above, however, are requested to respond to the current problems in a very short time and/or to carry out research only along the guideline of the government. Institutes under governmental organizations cannot carry out research on the topics whose fields cover several academic societies as they sometimes have very strict sectionalism. It is very difficult to expect the institutes belonging to governments to train the people in order to make them specialists in the field.

4. INCEDE ACTIVITIES DURING LAST 8 YEARS[2), 3)]

INCEDE was established with four full time staff, a professor, a visiting foreign professor, an associate professor and a research associate. During the last 8-year period, INCEDE has extended its strength from four full time staff to a total of 13 members, which includes 9 part-time research assistants. Also, time to time, INCEDE has been accommodating visiting researchers from different organizations within Japan and abroad. INCEDE has established three research laboratories, which function under the supervision of three faculty members of the center. In addition, eight laboratories of IIS act as cooperative members of INCEDE.

With this limited but dedicated work force, INCEDE has covered a wide range of activities from fundamental research to international cooperation in disaster mitigation. At present, INCEDE activities can be broadly divided into four groups as follows;

1) Research for disaster mitigation technology,
2) Reinforcing disaster related community network,
3) Disaster information dissemination, and
4) Reconnaissance surveys on natural disasters.

The main contents of different activities of these four groups are listed in the righthand side table.

INCEDE Activities

1) Research for Disaster Mitigation Technology
   - *Fundamental Research*
   - *Collaborative Research*

2) Reinforcing the network of disaster related communities
   - *Development of INCEDE Network*
   - *Exchange of MOU*
   - *Joint Research Projects*

3) Disaster information dissemination
   - *World Wide Web*
   - *INCEDE Publications*
   - *International Symposia/Workshops*
   - *INCEDE Open Lectures*

4) Reconnaissance Surveys on Natural Disasters
   - *Earthquakes, Floods, and Volcanic Disasters, etc*

4-1 Research for Disaster Mitigation Technology

One of the main objectives of INCEDE is fundamental research and development of new technology contributing to international cooperation through joint research with foreign researchers. INCEDE has covered three areas of research, which are as follows;

a) Urban earthquake mitigation engineering
b) Hydrology and water resources engineering
c) Application of RS/GIS to disaster mitigation research

With the above three areas, research activities of INCEDE can be broadly realized in two kinds; namely, Fundamental research and Collaborative research.

4-1-1 Fundamental Research

For conducting fundamental research and development of new technology on the three areas of research as mentioned above, INCEDE has established three research laboratories, which are headed by three professors of the Center. These three laboratories have their own students and researchers for conducting research works. The three laboratories and their major research areas are listed in the righthand side table.

Major Research Themses of INCEDE

Research Laboratory 1: Disaster Mitigation Strategies
- *Natural hazard risk analysis of developing world*
- *Geo-scientific and socio-economic origins of natural disaster*
- *International cooperation for natural disaster mitigation*
- *Disaster mitigation programs and knowledge transfer for developing world*
Research Laboratory 2: Hydrological Disaster Mitigation Engineering
- *Distributed hydrologic modeling*
- *Hydrologic disasters in Asian region*
- *Urban flood mitigation measures*
- *Hydrologic information system on disasters*
Research Laboratory 3: Urban Earthquake Disaster Mitigation Engineering
- *Real time control of large lifeline systems during earthquake*
- *Microscopic seismic risk assessment in urban areas*
- *Simulation of collapse process of structures due to an earthquake*
- *Human evacuation behavior analysis using virtual reality and computer model*
- *Dynamic behavior of interior objects during an earthquake, etc.*

Research Laboratory 1: Disaster Mitigation Strategies

There are 36 research centers affiliated to universities in the field of natural disaster in Japan. Only three of them are dealing with "international aspects" of the natural disasters. However two are oriented to socio-economic research. Thus it is the only research laboratory that studies natural disaster in terms of scientific and engineering and in the global aspect. There are very few such research organizations in the developed countries that focus on reduction of natural disasters in the developing world. The major research fields of this laboratory are explained below.

i) Natural Disaster Risk Analysis of Developing World

Most disaster prone countries in the developing world are making hard efforts to identify natural disaster risk with very limited resources. This laboratory studies how researchers in the developed countries can help in the identification and in putting identified issues into practice. As part of this study, the laboratory is deeply involved in the RADIUS project. It is an undertaking by the IDNDR Secretariat of the United Nations aiming to make risk assessment of urban areas in the developing world against earthquake disaster. INCEDE is carrying

out risk assessment of the Tashkent City, Uzbekistan Republic. In this work, we have paid our attention to the facts that most deaths have taken place at houses where people are living in most earthquake disasters such as Spitak earthquake of 1989, the Kobe earthquake of 1995 and Sakhalin earthquake of 1995. Based on the facts, peak ground motion on dwelling areas in Tashkent was estimated, based on the realistic rupture dynamics of the two faults, which run beneath the Tashkent City. The estimation has revealed that the near fields terms would made the ground motion larger than the estimation conventionally made.

ii) Geo-scientific and Socio-economic Origins of Natural Disaster

Earthquake, volcanic eruption, tsunami, floods, cyclones, and landslides are natural phenomena on the earth. Physical processes within or over the earth cause them. The energy released from these processes is so large that we can not prevent their occurence. These natural phenomena can affect human society adversely in some particular cases. It is the process that natural hazard becomes a natural disaster.

What are these particular cases? The quation in the righthand side explains the cases. The laboratory studies factors in the eqauation. These factors will be expressed in terms of scientific, engneering and socio-economics.

Equation expressing disaster in terms of scientific, engneering and socio-economics

$$D(t) = M \int_{\Sigma} \frac{G(\bar{r})}{E(\bar{r})S(\bar{r})} X(p) d\bar{r}$$

Where,
D = disaster measured by death toll, affected people and economic loss,
M = magnitude of hazard source
G = geo - scientific response
$\bar{r}$ = location coordinate,
Σ = area where society is built
E = engineering capacity,
S = society capacity
X = societal system, and
P = set of parameters, pk = f(D(t - τ))

iii) International Cooperation for Natural Disaster Mitigation

More than 70 countries in the world suffer earthquake disaster. More than 120 countries in the world suffer flood disasters. There are many similar experiences among these countries and a lot of lessons to be shared by them. The laboratory studies these experiences and lessons to identify research issues for further reduction of natural disasters and to find problems to be solved in the scientific and engineering aspects. In this context, the laboratory is concerned about what gap exists in sharing the technologies and knowledges in the international aid communities, such as JICA, GTZ, USAID, etc

iv) Disaster Mitigation Programs and Knowledge Transfer for Developing World

There are a couple of international initiatives toward global earthquake disaster reduction with emphasis on the developing world. One is World Seismic Safety Intiative (WSSI) an intitiative by International Association of Earthquake Engineering, IAEE. One of the objectives of WSSI is to increase the awareness of high-level decision-makers about earthquake disaster in earthquake prone countries. It is crucial to mobilize all resources for disaster redcution. Decision-makers should play a key-role. The laboratory studies how to stimulate or encourage such high-level people to take necessary actions toward earthquake disaster reduction. As part of this research, we are going to study cost benefit analysis of measures against disasters.

Research Laboratory 2: Hydrological Disaster Mitigation Engineering

Floods and water related disasters are the main causes of deaths due to natural disasters in the Asian region[4]. As a disaster category, they inflict the highest economic damage among all natural disasters in the region. Flood damage mitigation should be carried out either by control of the water through structural measures such as dam construction, river improvement, through non structural measures by providing space for water and ensuring that human activities do not exacerbate the flood hazards, or ideally, by a combination of the two. One pre-requisite for such flood disaster mitigation activities is the understanding of physical hydrological processes and the ability to anticipate the hydrologic response under various scenarios. This is especially difficult in the Asian region where long term observations of hydrological phenomena, necessary for the calibration of conventional mathematical models are few. For this purpose, the laboratory emphasizes on the development of numerical models based on the governing equations of water movement in all phases. They directly utilize physical catchment properties that are necessary when catchment characteristics change, either under human activities or natural phenomena. The models are applied for flood forecasting, damage estimation, flood reduction measures, water resources planning, coupling with climatic models, etc.

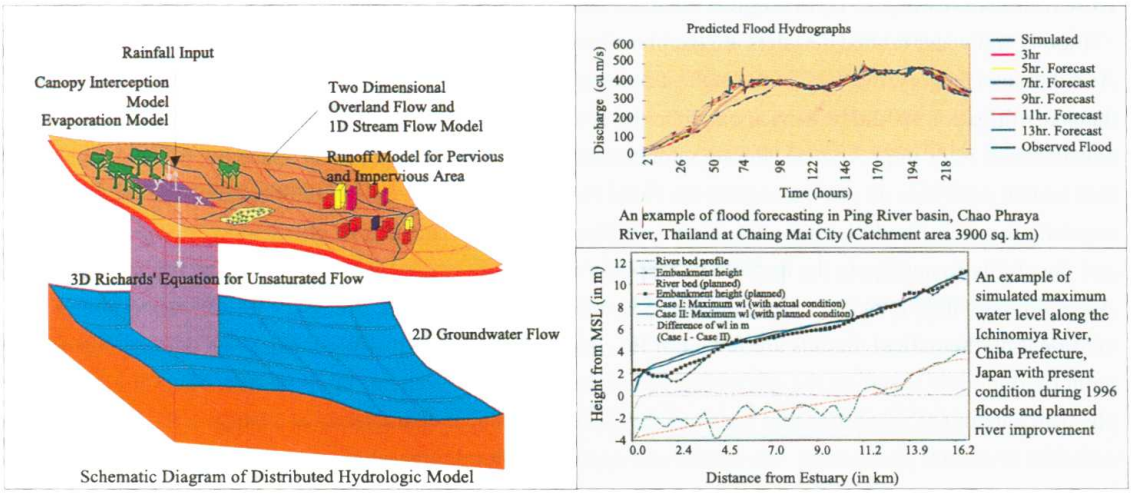
i) Distributed Hydrologic Modeling[5), 6), 7)]

Over the years, three different distributed mathematical models have been developed for applications to different sizes of catchments. They are, 1) A complete distributed mathematical model, which treats the water pressure as the state variable coupling interception, evapotranspiration, sub-surface flow, surface flow, groundwater flow and river network solutions, which has been applied in catchments ranging from 10 sq. km order with 50 m resolution data to 70,000 sq. km with 2 km grid resolution in Japan, Thailand and Philippines. 2) A model treating storage as the state variable that can simulate both natural as well as human water usage including water supply, drainage and irrigation has been applied in dense urban catchments with high spatial data resolutions. 3) A geomorphology based distributed model for application in very large catchments of order 100,000 sq. km which discretizes the catchments to slopes and river network using geomorphologic properties of the catchment It has been applied in several river basins in Japan and Thailand and in the Mekong basin covering up to 400,000 sq. km in extent.

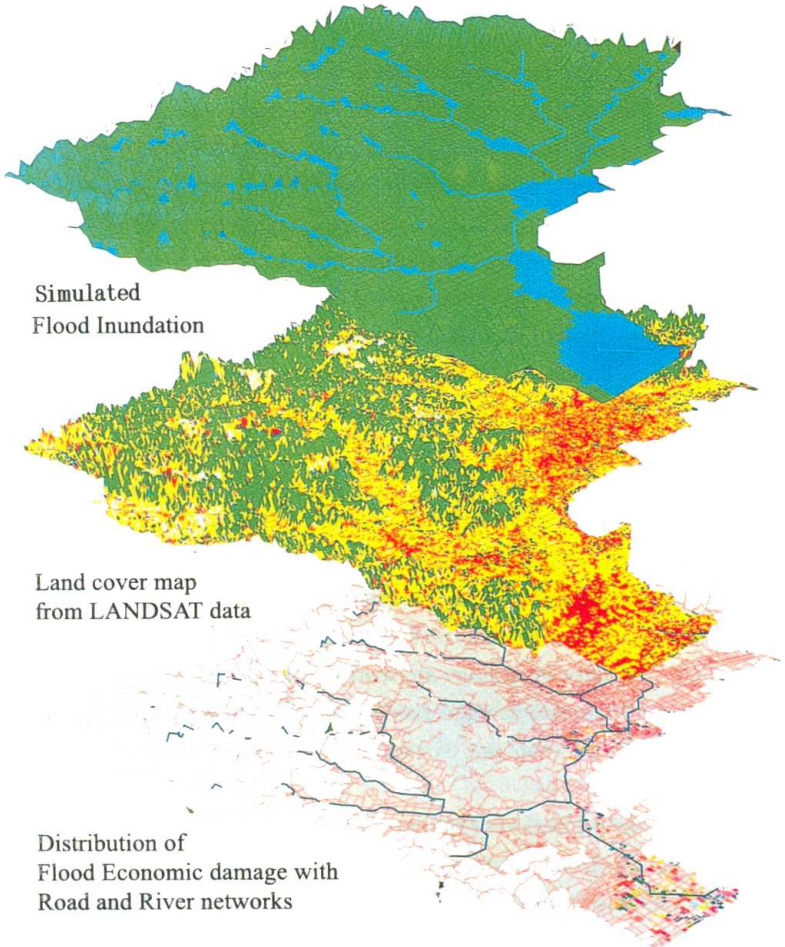
ii) Flood Modeling and Mitigation[8), 9)]

Mathematical models for flood inundation simulation and damage assessment are being developed. The second figure in the next page shows an application in Ichinomiya River basin, Chiba Prefecture, Japan, where the top figure shows the inundation simulation of a 1996 flood. The assets within the catchment, such as commercial and private buildings, industry, agriculture are spatially distributed utilizing remote sensing land classification. The 3rd layer shows economic damage distribution of residential buildings expressed in terms of million-yen per 50 m square grid area. Economic damage is estimated using depth-damage functions for different types of assets.

Another area of research is the utilization of infiltration facilities, such as trenches and wells to minimize direct surface runoff and increase ground water which in turn enhance the river base flows leading to better riparian environment. Optimum distribution of such on-site measures are investigated using distributed catchment models coupled to infiltration facility models in study catchments.



Concept of distributed hydrologic modeling and examples of its applications



Application of integrated flood simulation and damage estimation model in a Japanese river basin

iii) Hydrologic Information Exchange

Difficulties in applying distributed hydrological models to practical problems are the model complexity, large volume data and processing needs and training for proper use of such models. Internet based decision support system development is being carried out to enable remote users to use mathematical models available at INCEDE for flood forecasting and to visualize impacts of different decisions made. The system is developed on a central database, which stores hydrological data as well as knowledge for model execution and result analysis.

In addition to the above mention research topics, the researchers of the laboratory have been involved with many collaborative research projects. GAME and AP-FRIEND are two major on-going global research projects, where the laboratory members are activity involved. GAME (GEWEX Asian Monsoon Experiment) and GEWEX (Global Energy and Water Cycle Experiment) are ambitious programs designed to increase our understanding of global water and energy circulation in all its phases which would ultimately make it possible for long-term weather forecasts, to assess the human influence on global climate and to provide insight to moderate and control climatic variability and change. This laboratory is mainly involved in the hydrologic modeling research activities of the GAME project.

AP-FRIEND (Asian Pacific FRIEND) is responsible for the Asia-Pacific region of the FRIEND (Flow Regimes from International Experimental and Network Data) research program, an international collaborative study into regional hydrology with support of UNESCO. The primary objective of the FRIEND project has been to improve the understanding of hydrological science and to find solutions to practical water related problems.

Research Laboratory 3: Urban Earthquake Disaster Mitigation Engineering

This research laboratory has been studying disaster mitigation strategy in urban areas due to hazards mainly by an earthquake The objective of the research is to minimize human casualties and social ill function by well balanced countermeasures of hardware and software. The most important lesson we should learn from the 1995 Kobe earthquake is that the most important issues like human life and/or important information can be protected only by hardware measures, while minimization of social ill function and quick recovery/reconstruction from the damage should be implemented by real-time disaster mitigation systems and optimum recovery/reconstruction strategy. Based on these points, this laboratory has been tackling many research topics. Some selected research topics are only introduced here due to space limitation.

i) Development of New Model for Failure Analysis of Structures

To reduce human casualties, it is essential to understand the mechanism to collapse of structures. However, there is no simulation tool by which total collapse behavior can be simulated accurately. With the Applied Element Method (AEM), developed by Meguro and Hatem[10),11)] mechanism of structural damage to buildings and infrastructure is studied Unlike the finite element method (FEM), with the AEM, there is no need to assume the location and direction of a crack before analysis. Cracks can initiate at any location and propagate to any direction based on stress conditions. This model overcomes the problems of the FEM as mentioned above and also the problems of distinct element method (DEM) such as difficulty of application of static problems and effect due to the shape and arrangement of elements and long CPU time.