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Development and Implementation of Disaster Reduction Technology in Taiwan

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Abstract. In order to improve the efficiency of disaster reduction, the government of Taiwan has taken a number of initiatives in the development of disaster reduction technology since 1982, including the 1st, 2nd and 3rd 5-year plans for hazards prevention research, and the National Science and Technology Program for Hazards Mitigation (NAPHM). In this article, the contents and achievements of the 5-year plans and the NAPHM are briefly reviewed. On the one hand, the 5-year plans have produced meaningful research results; on the other hand, the NAPHM has provided a mechanism for integrating and translating the research results into technologies that can be implemented. The NAPHM was transformed in 2003 into the National Science and Technology Center for Disaster Reduction (NCDR) to further enhance the development and implementation of disaster technology. The mission and major future works of the NCDR are discussed.

Key words: disaster reduction technology, local disaster reduction plans, typhoon emergency response capability, disaster reduction education

1. Introduction

On average, Taiwan is besieged by 3.6 typhoons per annum, and at the same time, earthquakes occur frequently on the island as a result of tectonic plate collision. Therefore, typhoon and earthquake disasters are unavoidable. Although both the government and the people have made efforts to minimize losses of life and property caused by these disasters; in the last two decades, however, serious disasters have caused extremely

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great losses, indicating that efforts in disaster reduction must be further reinforced, especially in the area of disaster reduction technology.

In 1982, the National Science Council (NSC) launched a large-scale ''Research Program for Disaster Prevention'', and the Ministry of the Interior, Ministry of Economic Affairs, Ministry of Transportation and Communications, and Council of Agriculture started a series of programs for technological development in disaster reduction. In the meantime, as people's standard of living was improved, their demand for better protection of life and property against disasters was also gradually escalated. Therefore, the Executive Yuan (Cabinet) enacted the ''Disaster Reduction Plan'' in August 1994, and established the ''Central Disaster Reduction Meeting'', an overall mechanism connecting the central and local disaster reduction systems. In June 2000, the National Legislature passed the ''Disaster Reduction Act'' which was promulgated by the President in July of the same year. This established a legal basis for reinforcing disaster reduction programs.

In order to organize the research and development efforts in the related government ministries in a more systematic way, to integrate the research results and to transform them into useful applications in disaster reduction, the NSC reviewed and approved in 1997 the proposal to establish formally the ''National Science and Technology Program for Hazards Mitigation (NAPHM)''. The program was jointly planned and carried out by all the related units responsible for disaster reduction, emphasizing implementation and application, so as to tie research work closely with practice.

As technology forms the basis of disaster reduction, a long-term policy with persistent efforts in research is needed. Therefore, a permanent organization is required to coordinate the various participating ministries to set up a long-term research target, and to promote application of research results. Hence, in May 2003, the Executive Yuan issued the ''Directives for establishing the National Science and Technology Center for Disaster Reduction (NCDR)'', and in July of the same year, the Center was formally inaugurated.

For more than 20 years, the government of Taiwan has been making efforts to reinforce the effectiveness of disaster reduction programs. Enhancement of technological capability in disaster reduction is an important part of these overall efforts. This is accomplished through a series of important work including promotion of a large-scale research program, the creation of the NAPHM, the legislation of the ''Disaster Reduction Act'', and the establishment of the NCDR. All of these have had and will continue to have significant effects on Taiwan's development and application of disaster reduction technology. This paper summarizes the important aspects of these activities.

2. R&D Initiatives

2.1. LARGE-SCALE RESEARCH PROGRAM FOR DISASTER PREVENTION

This program consisted of three Five-Year Plans. The focus of the first Five-Year Plan was meteorology, flood protection, seismology, earthquake engineering and geotechnic engineering. In general, each subject area covered different disciplines of science, and was of practical, local and long-term nature. In the second Five-Year Plan, in addition to the subject areas of the first Five-Year Plan, two more were added: man-made disasters and the socio-economic issues in disaster prevention. The area of man-made disasters was dropped out of the research agenda in the third Five-Year Plan for lack of manpower to carry out the planned research work.

Generally speaking, all the Five-Year Plans have been successfully executed. During these 15 years, more than 1,000 research projects were carried out in academic institutes and related governmental units. Through these research projects, a large number of research personnel have been trained and a solid research capability has been established. At the same time, a large volume of scientific and technical results has been obtained. However, only a small proportion of these research results have been implemented in practice. Further analysis reveals that the reasons for the low ratio of applications are as follows (Yen, 1997, 1998).

- There is a lack of systematic channels for transferring research results into applications.
- It takes a longer time to transfer research results into applications than to publish research papers. Moreover, it is difficult to establish criteria for effective evaluation among projects of different subject areas.
- It is very difficult to persuade university faculty members to accept application-oriented research tasks, because publishing works in journals is often regarded as a matter of higher priority.
- It is difficult for different governmental units to cooperate and communicate among themselves because they often have different concepts for disaster reduction.

2.2. NATIONAL SCIENCE AND TECHNOLOGY PROGRAM FOR HAZARDS MITIGATION

The plan of establishing the NAPHM was first proposed in November 1997, followed by a year of preparation. The first phase of the program started in 1999 and ended in 2001. The second phase started in 2002 and will end in 2006. This is an integrated program across ministries and councils. The participating ministries/councils joined force with the NSC to

work out plans, and carry out promotion, execution, and integration, and finally transfer research results into application to disaster reduction (Yen *et al.*, 1997). A total of 12 ministries and councils, covering 19 units, participated in the program. The planned total budget of the program is NT$ 1,038 million for the first phase and NT$ 3,007 million for the second phase (Yen *et al.*, 2001).

Focusing on Taiwan's two most frequently occurred disasters – typhoon and earthquake, the NAPHM Phase I was so structured as to develop appropriate methodologies for disaster potential analysis, risk assessment and scenario simulation. Developed methodologies were then applied to draw up local disaster reduction plans for a few pilot project areas. Upon being fine-tuned, the methodologies were recommended to local governments for use in developing their own disaster reduction plans. A conceptual framework of the NAPHM Phase I is shown in Figure 1 below.

The main work of the NAPHM Phase I has been carried out smoothly with major achievements as follows (Yen *et al.*, 2001).

- Improvement in accuracy of flood and landslide forecasts, and the efficiency of evacuation and rescue operations by utilizing detailed local information about typhoon-induced gusts, precipitation and weather predictions.
- Completion of inundation potential maps for the Island of Taiwan.
- Development of a method for assessment of flood hazards, thereby constructing a relationship between inundation depth and flood loss.
- Establishment of a database and GIS for zoning of potential hazard areas such as Chenyulan Creek Watershed.
- Compilation of a complete, uniform earthquake catalog of Taiwan.
- Establishment of the relations between seismic damage and ground motion characteristics for Taipei Basin and Chia-Nan Area.
- Development of Haz-Taiwan Earthquake Loss Estimation Model to conduct seismic disaster scenario simulations for selected demonstration areas.
- Establishment of appropriate methodologies for urban earthquake hazard risk assessments and hazard scenario simulations of urban fires, evacuations (sheltering) and rescues, and economic losses.
- Development of decision-support systems, which integrate hazard scenario simulation methodologies within a GIS context, for hazard mitigation, preparedness, response and recovery.
- Development of disaster reduction plans for Taipei City and Chiayi City as demonstration projects for application of disaster reduction technology.

As it became clear that the results produced by the NAPHM Phase I were meaningful and useful as mentioned above, all the participating ministries

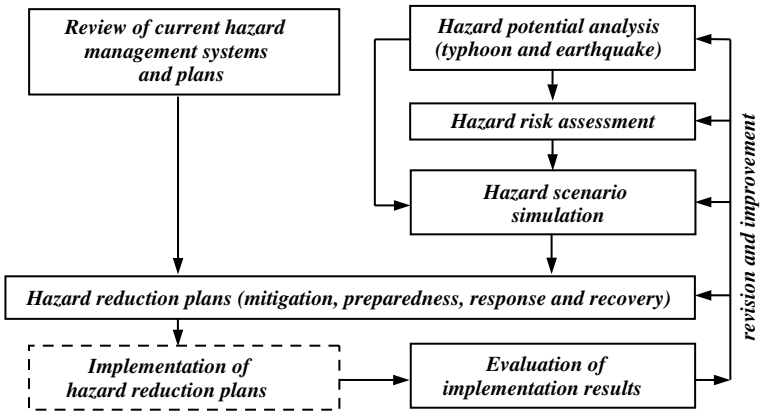

Figure 1. Conceptual framework of the NAPHM Phase I (Yen *et al.*, 1997).

and councils recognize that the disaster reduction is a very long-term task involving disaster potential analysis, risk assessment, land use planning and management, organizations, public education, financing, taxation, insurance and disaster reduction evaluation. All of these are related to technology in one way or another. Therefore, the NAPHM Advisory Group decided to recommend continuation of the program for another 5 years as the NAPHM Phase II.

The NAPHM Phase II emphasized accelerating development of technology for disaster reduction and intensifying application of technology to disaster reduction. In addition, topics related to the Chi–Chi Earthquake disaster are also included. The planning of Phase II was started in March 2000. A consensus was reached among participating ministries/councils after many deliberations. The planning report was finalized and approved by the NSC in September 2000. The main areas of work planned, as shown in Figure 2, include (1) hazard potential analysis and risk assessment, (2) policies and regulations, (3) application and implementation (including mitigation, preparedness, response, and recovery), (4) social and economical issues in disaster reduction, (5) information and decision-support systems, (6) institutions of disaster reduction, and (7) hazard scenario response exercise (Yen *et al.*, 2001).

2.3. LEGISLATION

As mentioned earlier, the National Legislature passed the ''Disaster Reduction Act'' on June 30, 2000. It was then promulgated by the President for enforcement on July 19 of the same year. The Act is comprehensive and pioneering to some extent. Disaster reduction-related scientific research and development items are explicitly stipulated in the Act. For

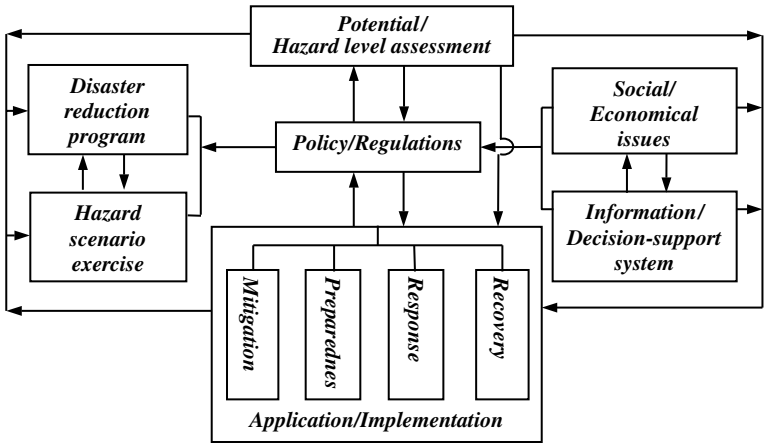

Figure 2. Framework of the NAPHM Phase II (Yen *et al.*, 2001).

example, in order to reinforce the implementation and application of research results, the Act states clearly that a science and technology center for disaster reduction is to be established to promote application of disaster reduction technology. In addition, advisory committees comprising experts should be formed to provide advice in disaster reduction at all levels of government. All levels of government should reinforce the application of disaster reduction technology, carry out disaster potential survey and analysis, hazard risk analysis, and scenario simulation with scientific methods, and publish the results of the survey and analyses in time (Chen, 2002).

Furthermore, Article 20 of the ''Disaster Reduction Act'' stipulates that: organizations responsible for disaster reduction at municipality/county level should work out their rescue programs in accordance with disaster potentials of their particular area.

3. Important Experience

3.1. CONSOLIDATION OF R&D EFFORTS

Since the NAPHM is an inter-ministrial program, a common platform for interactions among the participating ministries must be provided. A program office is therefore organized for this purpose. In order to carry out the various tasks effectively, the day-to-day operation of the NAPHM is run by the ''Program Office'' under which are a working group, expert teams and research teams. The mission of the Program Office includes planning, coordination, integration and management. In addition, there are a supervisory group and an advisory group. The members of the supervisory

group are vice-ministers of the relevant ministries/councils, while the members of the advisory group include scholars and heads of those agencies responsible for disaster reduction operations. The operational flow chart of the NAPHM is shown in Figure 3.

The major R&D topics are proposed by the working group in consultation with the advisory group and finally approved by the supervisory group. In consideration of the needs in disaster reduction of the ministries, the results of R&D are monitored continuously, and transferred into applications as appropriate. This model of the NAPHM operation has proven that the proceeding from research to application can be significantly accelerated, and that the needs of the ministries can be better met. Interaction between the NAPHM research teams and research units of the ministries are especially encouraged.

As there are many ministries/councils participating in the NAPHM, there is a need for very coherent coordination among the various components of the Program Office. Although the office of the NAPHM served some functions of coordination and integration, its manpower is unstable because it is operated on a project basis. Under this circumstance, it is rather difficult to aim at a long-term target in promoting application of research results. The establishment of the NCDR is to overcome this difficulty. The NAPHM is now integrated with NCDR under which continuous devotion and investment, accumulation of experience, and periodic updating of database and technology in disaster reduction can be assured.

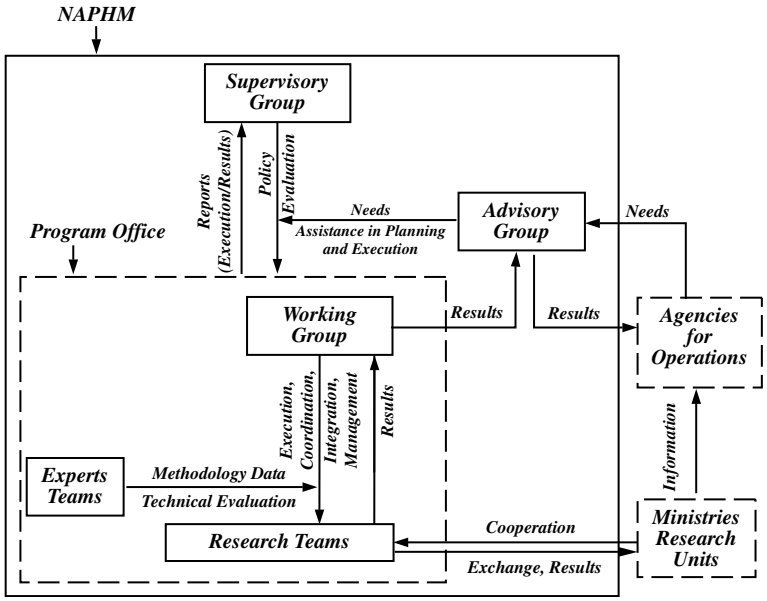

Figure 3. Operational flowchart of the NAPHM (Yen *et al.*, 1997).

As the technical arm of the nation's disaster reduction system, the NCDR operates under the joint auspices of the National Disasters Prevention and Protection Commission (NDPPC) and the NSC. Its inter-relations with other institutions are shown in Figure 4, which is self-explanatory.

The main functions of the NCDR include research promotion, technical support, and implementation/application. The major tasks under these functions are as follows (Loh *et al.*, 2001).

1. R&D Promotion
   (1) Planning of R&D agenda.
   (2) Coordination of collaborating research institutes.
   (3) Review of R&D programs for related ministries.
   (4) Policy studies.
   (5) Survey and assessment of major disasters.
2. Technical Support
   (1) Assisting in mitigation operation programs.
   (2) Assisting in disaster potential analysis and scenario simulation.
   (3) Assisting in establishment of monitoring and warning systems.
   (4) Assisting in establishment of information systems for disaster reduction.
   (5) Supporting emergency response operations.
3. Implementation/Application
   (1) Translating research results into applications.
   (2) Information sharing and database maintenance.
   (3) Assisting in establishment of operation code/guidelines.

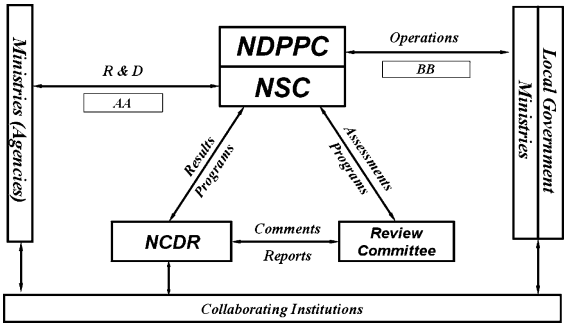

Figure 4. Inter-relations of NCDR with others (Loh *et al.*, 2004). NDPPC: National Disasters Prevention and Protection Commission; NSC: National Science Council; AA: planning for topics, selection of participating organizations, evaluation of results, follow-up on deployment and application, etc.; BB: planning for disaster reduction systems, development of disaster reduction plans, establishment of disaster monitoring and warning systems, establishment of information systems, disaster reduction preparedness and exercise, etc.

(4) Assisting in assessment of mitigation capabilities and needs.
(5) Assisting in review on programs and resource demand.
(6) Appraising effectiveness of R&D programs.
(7) Development of educational materials for disaster reduction.
(8) Training professionals for disaster reduction.

3.2. COLLABORATION WITH LOCAL GOVERNMENTS

In 1999, the NAPHM Office entered into an agreement with Taipei Municipal Government to transfer systematically disaster reduction technologies resulting from R&D work. A similar agreement was also signed with Chiayi Municipal Government in 2001. The NAPHM Office had organized a technical team each for Taipei and Chiayi to assist in carrying out: (1) flood and debris flow disaster potential analyses, (2) earthquake disaster assessment and decision-support systems application, (3) establishment of disaster management decision-support systems, (4) planning and establish-

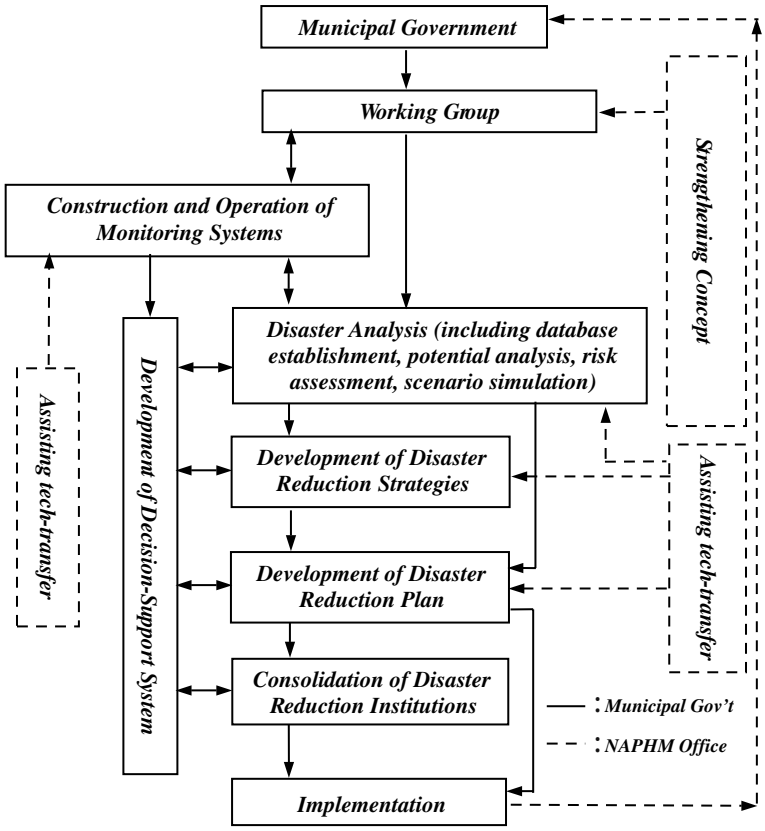

Figure 5. Framework of Collaboration Project for Disaster Reduction.

ment of institutions for disaster reduction and emergency response, and (5) planning of disaster reduction plans and so on.

Taipei City and Chiayi City started to implement their disaster reduction plans on May 17, 2000 and March 14, 2002, respectively. Both had completed the implementation by the end of 2003. The flowchart of the collaborative work is shown in Figure 5. The collaborations have made many achievements, and this collaboration model is being introduced to other local governments. The following are some examples of the achievements (Loh *et al.*, 2002).

- Integration of rainfall and flood information into decision-support systems has enhanced the efficiency in flood disaster reduction, and changed the characteristics of the work from passive handling to active prediction for preventive measures to be taken beforehand.
- Establishment of criteria for early warning of landslide disasters, and delineation of potential landslide areas have enabled Disaster Emergency Operation Center to issue warnings and order evacuation of residents in the hazardous areas.
- Earthquake disaster scenario simulations carried out for assessment of disaster loss and planning of evacuation routes have been successfully tested against the earthquake event of March 31, 2002 in Taipei.
- The results of planning and development of database, monitoring systems, and decision-support systems have been employed in handling of disaster mitigation and emergency response.
- A comprehensive "municipal disaster reduction plan" by integrating component programs under various departments of the municipal government has been completed and followed up in operations.
- A single institution in charge of the disaster reduction plan under the municipal government has been organized and is functioning.
- Through participation and practice, the working teams of both municipal governments have shown substantial improvement in disaster reduction operations during typhoon attacks in the last 2 years.

3.3. DEVELOPMENT OF LOCAL DISASTER REDUCTION PLANS

Through the experience gained in collaborative projects mentioned above, a comprehensive disaster reduction plan can be developed for each local government (city/county) with the following aspects included: (1) a steering committee for disaster reduction, (2) strategy and measures for disaster reduction, (3) thorough investigation of the characteristics of disaster in the jurisdiction, (4) all kinds of disasters at various stages, (5) integration of works and expenses of various departments, (6) preparation and use of relevant information, and (7) mechanism for evaluation of implementation.

On the basis of the above aspects, the program should be documented and presented in the following sequence: (1) general provisions (including program study and planning, general situation of the programmed area, departments related to disaster reduction and the general work outline), (2) all kinds of disasters (each with disaster mitigation, preparedness, emergency response and recovery aspects), (3) plan expenses and implementation evaluation, and (4) supplementary articles. The disaster reduction program with the process involved is shown in Figure 6.

Local governments are at the forefront of disaster reduction. However, at present, most of them lack the manpower and technological resources needed to carry out the work. Hence, in the Central Disaster Reduction Meeting of May 2003, a resolution was passed: "While the local disaster reduction plans are important basis for the local governments to carry out disaster reduction, the national government has the responsibility to provide the local governments with technology, experience, and resources to help them work out complete and comprehensive plans... ". As a result of this resolution, a 3-year program was formulated with the following targets:

- Assisting the local governments in development of comprehensive disaster reduction plans, and its implementation through budgeting evaluation processes.

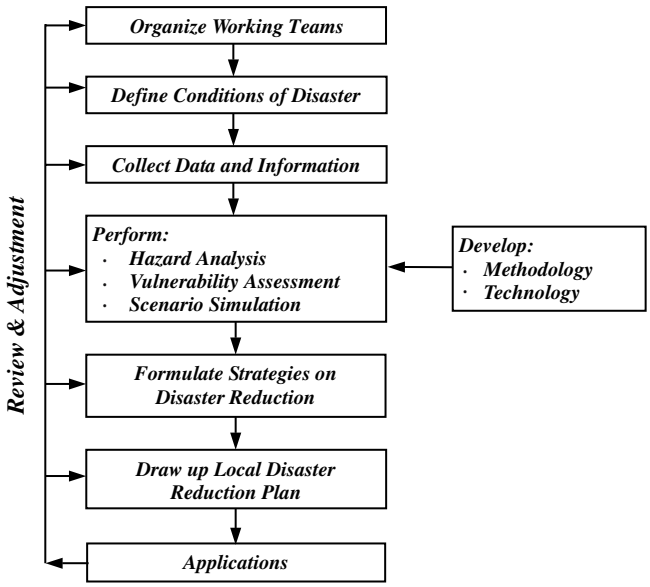

Figure 6. Flowchart for development of local disaster reduction plan.

- Assisting in transfer of disaster reduction technologies to the local governments, and their applications to development of strategies and measures for disaster reduction work.
- Assisting in training of local governments' professionals for disaster reduction so as to upgrade their expertise, thus enhancing quality and efficiency.

3.4. ENHANCEMENT OF TYPHOON EMERGENCY RESPONSE CAPABILITY

During the typhoon season in Taiwan, severe flood disasters often occur. Under this circumstance, the National Disaster Emergency Operation Center (NDEOC) is activated whenever typhoon warning is issued. The operational frame of the NDEOC Assessment Group and duties of the Group members are shown in Figure 7. The NAPHM Office has always provided technical supporting service to the center since the year of 2001. Whenever it is needed, a team of experts from the NAPHM is dispatched to the center to work on predicting and mapping the possible areas of flooding and debris flow. The real time data of rainfall and river stage are furnished by the Central Weather Bureau and Water Resources Agency, respectively.

Take Typhoon Nari of September 2001 for example. The NAPHM Office provided the disaster potential maps, as shown in Figures 8 and 9 in time for the NDEOC to decide on actions to be taken. Through coordination among the relevant ministries, evacuation of residents from the poten-

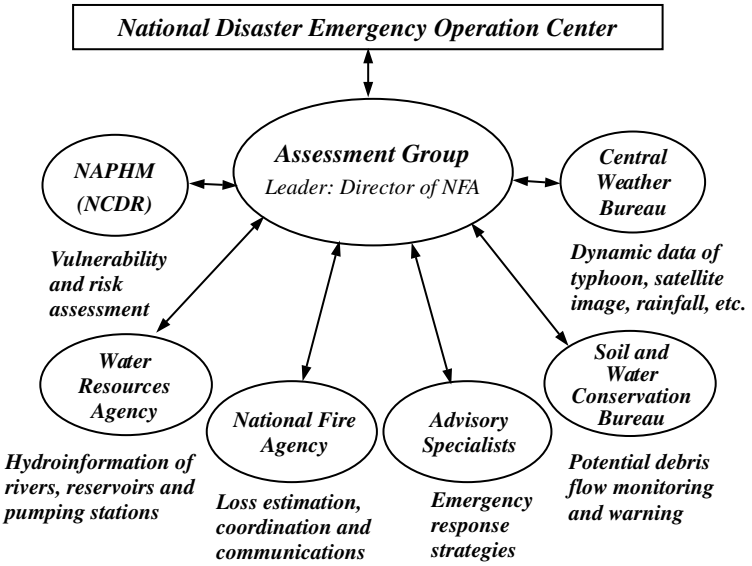

Figure 7. Operational framework of NDEOC Assessment Group.

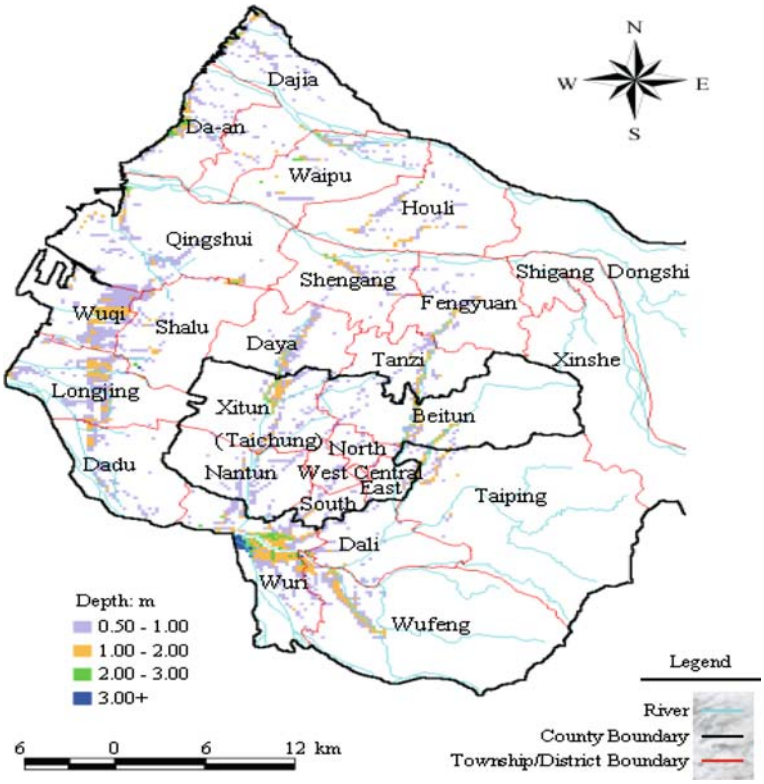

Figure 8. Inundation potential map in Metropolitan Taichung City and County during Typhoon Nari, 2001 (Loh *et al*., 2002).

tial disaster areas was decided. The number of evacuatees exceeded 24,000, and this has shown to be a quite effective way of reducing the number of casualties.

3.5. TECH-TRANSFER OF SEISMIC LOSS ESTIMATION SOFTWARE

In order to mitigate seismic disasters and to reduce catastrophic risks, it is necessary to have adequate damage estimation and risk management strategies, not only on ordinary days but also in emergency. The strategies must be formulated using reliable information that comes from inventory database, past experiences, and appropriate scenario simulations. Therefore, development of seismic scenario simulation technology is very important in countries that suffer from earthquake threats.

Taiwan has developed an integrated GIS-based software, ''Haz-Taiwan'', to estimate ground motion intensity, ground failure extent,

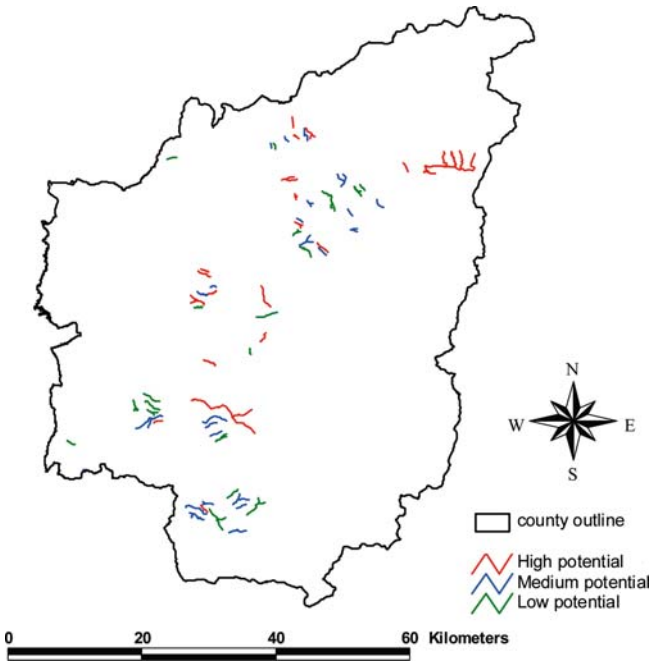

Figure 9. Debris flow potential map for Nantou County during Typhoon Nari, 2001 (Loh *et al*., 2002).

damage probabilities/quantities of civil infrastructures and pipeline systems, induced socio-economic losses, and so on, when and if strong earthquakes attack. The software Haz-Taiwan can provide useful data for seismic disaster mitigation plans in normal times for all levels of government. It can also provide useful data for proposing emergency response actions soon after strong earthquake occurrences, and serve as a decision-support system for actions to be taken to dispatch rescue forces and medical resources.

In the process of developing the local disaster reduction plan, Taipei municipal government has employed the software Haz-Taiwan to carry out seismic scenario simulation, risk assessment and loss estimation. The seismic disaster mitigation and emergency response plans were drawn up according to the results obtained from Haz-Taiwan. Shown in Figure 10 is an example of the output from Haz-Taiwan for Taipei City (Yeh *et al*., 1999.

The software has since been upgraded and renamed Taiwan Earthquake Loss Estimation System (TELES). Efforts have been made to transfer this technology to governmental units responsible for development of disaster reduction plans. It is expected that TELES will be widely employed in Taiwan.

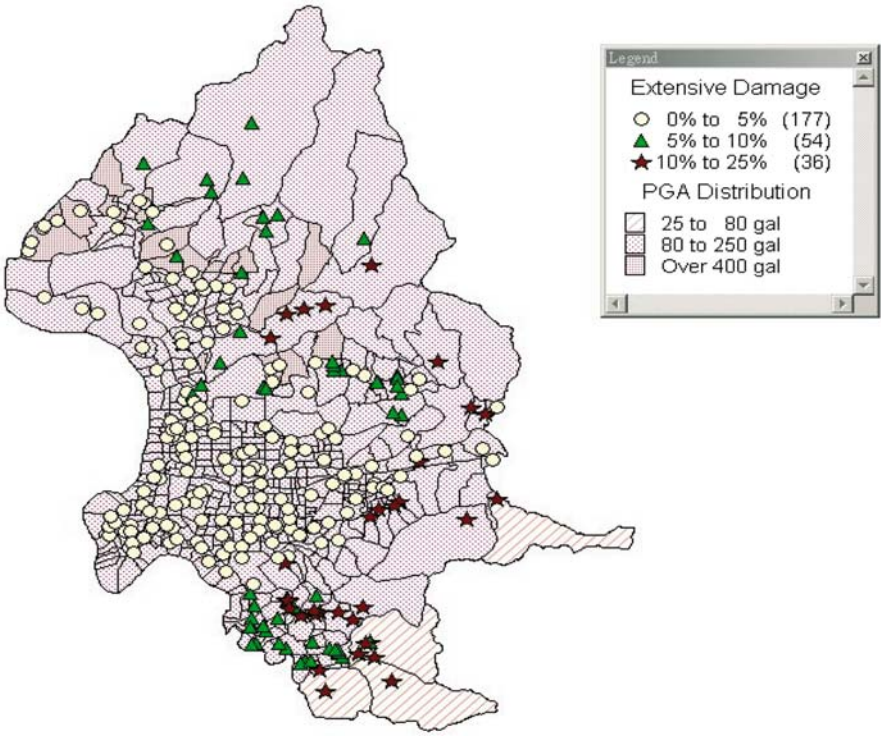

Figure 10. School building damage estimation for Taipei City (Yeh *et al*., 1999).

4. Future Works

4.1. DATABASE AND DECISION-SUPPORT SYSTEM

At present, many databases for disaster reduction have been built by governmental units, but most of them are scattered in different ministries, and difficult to integrate. In addition, most of the decision-support systems used in operations are mainly for disaster management, but their functions are incomplete. Therefore, they can only provide limited information for decision-making. As part of the government's efforts to strengthen the nation's information system, a project named ''Disaster Reduction Information System'' was initiated in 2002. Its main tasks are to upgrade the database and decision-support systems for disaster reduction operations, and in addition, to establish an information system for disaster reduction education.

In the process of carrying out the tasks stated above, special attention will be given to the following points:

- Standardizing classification, format, quality of data and procedure for data updating.

- Adopting an open type of GIS technology to integrate the spatial geographical information scattered in different governmental units, and NGOs.
- Integrating the existing disaster reduction database under distributed architecture.
- Establishing a common platform for the disaster reduction database.
- Strengthening the mechanism for information sharing and maintenance.

4.2. APPLICATION OF REMOTE SENSING TECHNOLOGY

Remote sensing technology such as Synthetic Aperture Radar (SAR) and Interferometric Synthetic Aperture Radar (InSAR) can provide effectively observed information for different types of disasters. They can be used to monitor field situation of disaster and thereby to assess losses in a large area. The information so obtained can be utilized in conjunction with GIS data for decision-making in different phases of disasters. In recent years, high-resolution satellite images have also provided effective information for disaster reduction. Therefore, research and development on their utilization should be carried out. The ROCSAT 2 satellite, launched on May 21, 2004, provides a good opportunity for application in this regard. The ROCSAT 3 satellite, which is an array meteorological monitoring satellite, is planned to be launched in 2005. Therefore, now it is the time to promote application of remote sensing technology in environmental monitoring for disaster management.

In the next few years, the efforts to promote application of remote sensing will be concentrated on the following:

- Intensifying study on the application of remote sensing information provided by ROCSAT 3 to disaster reduction work.
- Upgrading capability for disaster monitoring and investigation by well-developed high technology, such as airborne radar, high spectra telemetering and radar scanning systems.
- Developing and implementing a comprehensive land use monitoring program.
- Establishing a multi-functional telemetric data integration center for integration of data from different time and sources.
- Expanding participation of private sector and training program for professionals.

4.3. SUSTAINABLE LAND USE MANAGEMENT

With its special geographical environment, Taiwan is frequently affected by natural disasters caused by severe typhoons and earthquakes as mentioned

earlier. In recent years, the land around urban areas and low-lying areas near rivers have been quickly occupied and exploited in large scale. As a result, the risk of large-area landslide, debris flow and flood disasters has drastically increased. The fundamental way to reduce the risk of these disasters is to avoid improper land exploitation, reinforce environmental conservation, strengthen the monitoring and early warning in highly hazardous areas, and intensify land use management. However, these measures are often in conflict with the short-term interest of some sectors. Consequently, implementation of these measures encounters strong resistance. Further study will be made to find solutions to these problems so as to ensure sustainable land use. For this purpose, the development of technology for land use management will be focused on the following:

- Integrating effectively the land use management mechanism with the disaster reduction operations system.
- Intensifying research on land use development and ecological engineering related to disaster reduction.
- Establishing a disaster risk assessment system for land use planning.

4.4. DISASTER REDUCTION EDUCATION

In recent years, Taiwan's governmental units at all levels and NGOs have become more and more aware of the importance of disaster reduction education, and therefore have increased investment in related activities. However, some problems still remain to be solved. For example, only about 2% of colleges offer common education in the disaster-related field, and most courses only introduce one single type of disaster and rarely mention the other types. Disaster reduction education stresses particularly on pre-disaster preparedness and emergency response during disasters. Little is mentioned about mitigation and recovery. In the meantime, although governmental units have some education resources, they are independent and there is little collaboration.

The aim of disaster reduction education is to enrich people's knowledge about disasters, and to enhance their capability in reducing the risks and losses under the circumstance of disasters. After an overall review of the current programs, the technological aspects of the following items are to be stressed in disaster reduction education:

- Enhancing the awareness of disaster reduction.
- Planning courses and compiling teaching materials for disaster reduction.
- Expanding channels of learning the subject courses.
- Upgrading teaching facilities.

- Training specialized teachers.
- Developing an evaluation system for disaster reduction education.

5. Conclusions

On the basis of the discussion above, the following conclusions can be drawn.

1. Since 1982, Taiwan has taken a number of initiatives in research and development for improvement of disaster reduction. The R&D Programs carried out under these initiatives have produced a large volume of scientific and technological results, some of which have been successfully transformed into applications in disaster reduction.

2. From experiences gained in the execution of the R&D programs, it is learned that consolidated planning, coordination and management are critically important because the subject areas for research and development in disaster reduction technology are of highly interdisciplinary and inter-ministrial nature.

3. For application and implementation of R&D results, special efforts in the forms of technology-transfer, technical support and collaborative work are necessary. However, the legislation stipulating that all levels of government should reinforce the application of disaster technology certainly is a very powerful tool for accelerating implementation of technology in disaster reduction plans at all levels.

4. For further development of disaster reduction technology in Taiwan, it is suggested that emphasis in the future works should be placed on the following subject areas: integration of database and decision-support systems, application of remote-sensing technology to environmental monitoring for disaster management, development and application of technology for land use management, and incorporation of technological aspects into disaster reduction education.

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