



Disaster Prevention and Rescue Information Service Platforms

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Abstract: Because of its special hydrology and physiographic environmental conditions, Taiwan experiences a wide range of natural disasters, such as typhoons, floods, slope collapses, debris flows, and earthquakes, resulting in the loss of many lives and properties. Integration of disaster-related information, such as data and models, and the analysis and application of the information are crucial to reduce the damage caused by natural disasters. Therefore, the National Science and Technology Center for Disaster Reduction introduced the information service platform technology of the Research Development and Evaluation Commission to integrate the information of related ministerial departments for added value and use. Related technologies have integrated information of disaster prevention and rescues, assisted the government in disaster prevention and rescue, and effectively reduced the time required for information integration. Additionally, the added value of information applications enabled situational analysis and process handling during natural disasters. This study uses responses to typhoons as examples, and describes how the service application platform of disaster prevention and rescue is used to integrate various data in the response processes and employs related systems to provide users real-time information as a reference for subsequent decision-making.

Keywords: disaster prevention; rescue service; geographical information systems; typhoon monitoring

Introduction

The World Bank commissioned the Earth Institute at Columbia University to conduct a study on global disaster hotspots. According to the report, 73% of Taiwan's land area and people are exposed to at least four natural disasters. This ratio is the highest in the world, meaning that Taiwan is among the locations most likely to experience natural disasters [1]. Regarding disaster responses, the automatic integration and application of various data can accelerate disaster responses. Therefore, the most crucial issues in the application of disaster prevention information are to integrate data of disaster prevention and rescues with

the related models of each ministerial government department, and to analyze disaster response processes using tools such as geographical information systems, internet technologies, and user interfaces.

The integration of disaster-related image data has become an indispensable technology in disaster prevention and rescue both domestically and internationally. Furthermore, GIS technology of geographical information systems has long been widely used in the space management and analysis of disaster information [2-4]. Specifically, GIS applications provide decision makers with direct and effective information analysis of disaster responses, assisting them in deciding disaster responses and adjustments. For example, the Pacific Disaster Center (PDC) [5] used relevant technologies to enhance the disaster management and



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Chun-Hung Huang was graduated from Institute of Water Resources and Environmental Engineering, Tamkang University, Taiwan. Since 2004, he joined National Science and Technology Center for Disaster Reduction (NCDR), Taiwan. His major tasks are system setup and development and database management. He has developed historical disaster information system, poisoning disaster decision support system, and disaster reconnaissance systems. As for database management, he is responsible for planning, building, maintaining anti-disaster data warehousing, which contains data such as texts, maps, remote sensing images, and other aircraft images. He will continue to put more efforts on collection of national disaster data and the implementation of disaster prevention information sharing mechanism in the future.

Shang-Yu Wu was graduated from Department of Geography, National Taiwan University. His specialties include: Geographic Information System and applied information system for disaster planning. He is with National Science and Technology Center for Disaster Reduction (NCDR), Taiwan, for the time being and his research topics include: automation of flooding model, automation of debris flow model, real time rainfall data processing and warning message sending service, disaster operation support system, disaster analysis and judgment report system, and disaster operation decision-making support system.

Jerry Chow joined National Science and Technology Center for Disaster Reduction (NCDR) in 2003. His major tasks include: applied information management, the setup and running of disaster prevention information service platform. This year, this disaster information database is open to public via a website portal.

Mei-Chun Kuo was graduated from Department of Civil Engineering, National Taipei University of Technology, Taiwan. After graduation, she has been doing all kinds of tasks related to Geographic Information System (GIS) in many academic and public organizations. These GIS related tasks include GIS technical support, GIS basic concept providing, GIS geometry editing verification, GIS space analysis, GIS 3D analysis, and GIS database setup and archiving. She was ESRI licensed lecturer for education training. After joining National Science and Technology Center for Disaster Reduction (NCDR), she has researched and set up the earthquake disaster prevention and rescue demo platform, summarized Morakot typhoon's damages and loss, drafted the GIS disaster analysis map, developed the GIS computational module of the household loss model for flooding, and planned and set up the national disaster decision support system.

Pai-Hui Hsu received his B.S., M.S. and Ph.D. degrees in surveying engineering from the National Cheng Kung University, Taiwan, in 1993, 1995 and 2003. He is currently an assistant professor in the department of Civil Engineering at the National Taiwan University, and he is also the secretary general of Taiwan Geographic Information Society (TGIS). His current research interests include image processing of remote sensing, geospatial data analysis in GIS, disaster information management, and wavelet theory.

Hsueh-Cheng Chou is the Associate Professor of geography, National Taiwan Normal University (NTNU) and Division Head of Information Division National Science and Technology Center for Disaster Reduction (NCDR). He specializes in Geographic Information System and supervising the development of a decision support System for CEOC (The Central Emergency Operations Center). He is the vice chairman of the GIS committee of The General Chamber of Commerce, promoting the use of GIS for business industries. He also heavily involves in Nation Geographic Information System, which coordinates the development of GIS in government agencies. Before he studied GIS at State University of New York at Buffalo. He had participated in multidisciplinary environment research projects in Taiwan. These experiences have helped him to communicate with experts from various domains and designing information systems for them.

risk assessment of the Pacific Rim, improve disaster reduction strategies, and facilitate decision-making and activity planning for the entire area, including the assessment of the impact of various disasters. The PDC displays disaster-related messages using innovative information technologies and through visualization with geographic image data of Pacific Rim countries to help these countries conduct disaster prevention decisions. Additionally, consider the Great East Japan Earthquake for example, the Japanese government established an "emergency mapping team (EMT) [6]" through cooperation between the government and citizens to ensure the related responding personnel understand the overall disaster and disaster relief conditions. After the earthquake, various types of maps were provided through the platform, enabling people to quickly obtain required information. Additionally, the released image data can be used in subsequent added-value applications.

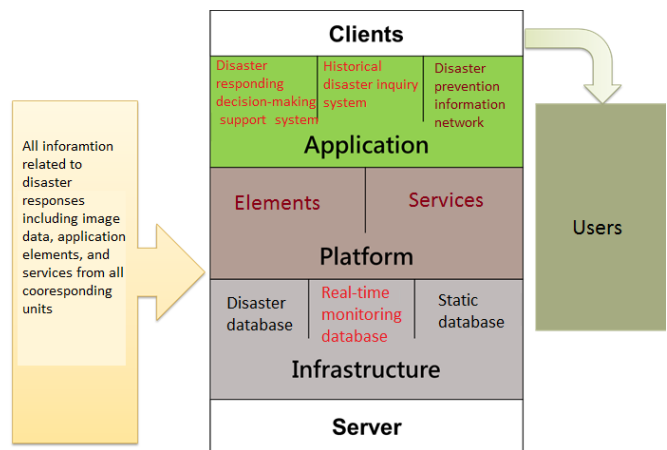


Figure 1. Architecture of the disaster prevention and rescue application platform.

Taiwan has conducted numerous basic studies in the field of natural disasters. However, an integrated information service platform is required to implement the research results in practical applications. The National Science and Technology Center for Disaster Reduction (hereafter referred to as the Center) introduced the information service platform technology of the Research Development and Evaluation Commission, Executive Yuan, and progressively established a service application platform for disaster prevention and rescue and related subsystem applications by employing a geographical information system and Internet technologies [7-9]. The major functions of the information service platform are to share information, promptly connect the image data of the ministerial government departments, and directly apply the information to each system through the serial connection services of the platform. The Center has



developed a disaster response decision-making assistance system, a mobile message notification system, and a historical disaster information system using related image data; the Center also employed a service-oriented architecture (SOA) to release relevant services to other units. Each of these systems is used at different stages of disaster response, enabling the disaster prevention and rescue data and information of the ministerial government departments to exert the maximum effect during disaster responses. The technology for establishing the service application platform for disaster prevention and rescue and the applications of each system for disaster response are introduced below.

Disaster Prevention and Rescue Service Platform

Because of global climate changes, the climate is becoming increasingly extreme. Additionally, a single disaster is likely to induce other disasters, resulting in complex disasters. For example, the tsunami caused by the Great East Japan Earthquake in 2011 not only claimed the lives and properties of the coastal residents, but it also triggered the explosion of oil refineries and, even worse, the meltdown of nuclear reactor cores and radioactivity leakage. Under large-scale complex disasters, such as Typhoon Morakot, Taiwan suffers different types of large-area effects, such as slope collapses and flooding. These events highlight the

importance of integrating applications of current disaster prevention and rescue information [10]. Therefore, the Center has accelerated the establishment of platform-related construction. Besides the construction of physical platform hardware, the Center also considers relief responses to typhoons to be a major aim of planning and constructing information interworking. The procedure of employing disaster response information applications in responses to typhoons can be divided into four major stages (Figure 2):

Analysis and simulation of early warnings

When issuing a typhoon warning, the government must understand the potential impact of the typhoon. Thus, they must employ related prediction model literature, historical disaster information, and related basic information to analyze and simulate the early warning and understand the potential damage the typhoon might cause.

Monitoring

When a typhoon approaches Taiwan, related monitoring information becomes increasingly important. The conditions can be displayed through real-time monitoring information and the displayed information can be used as a reference for subsequent countermeasures.

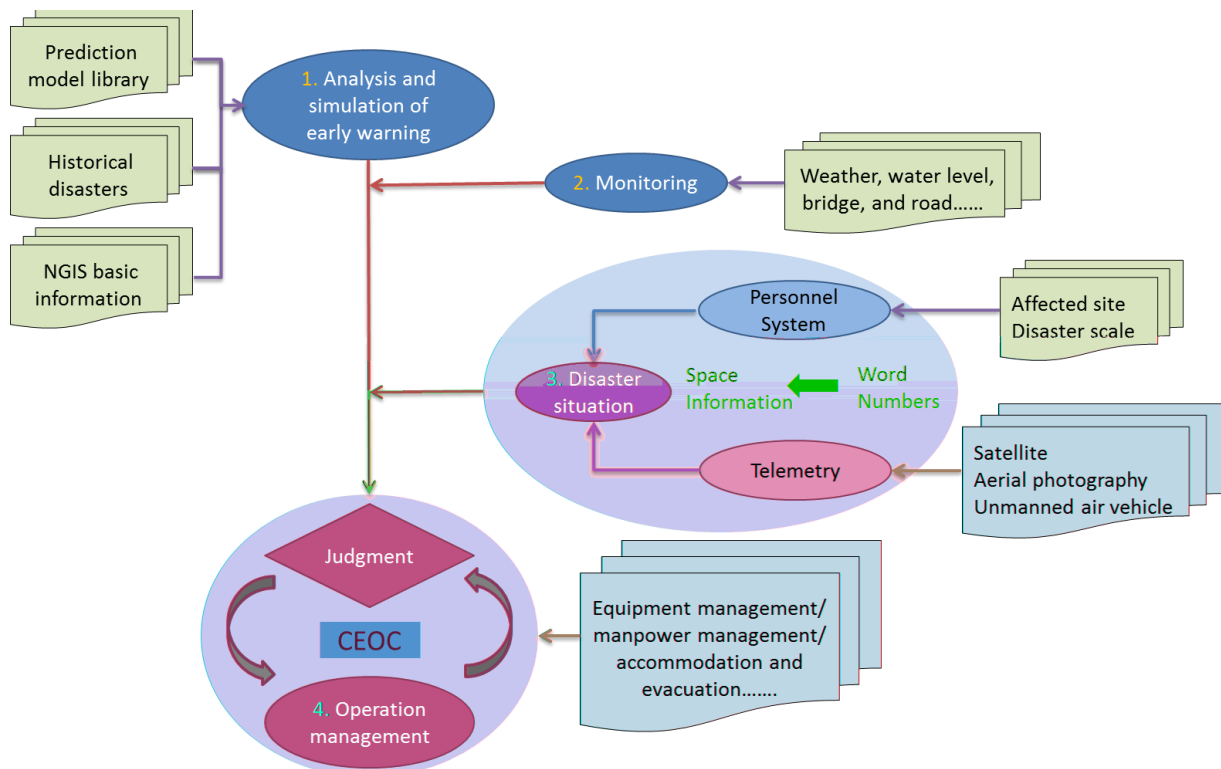


Figure 2. Application procedure of responses to typhoons

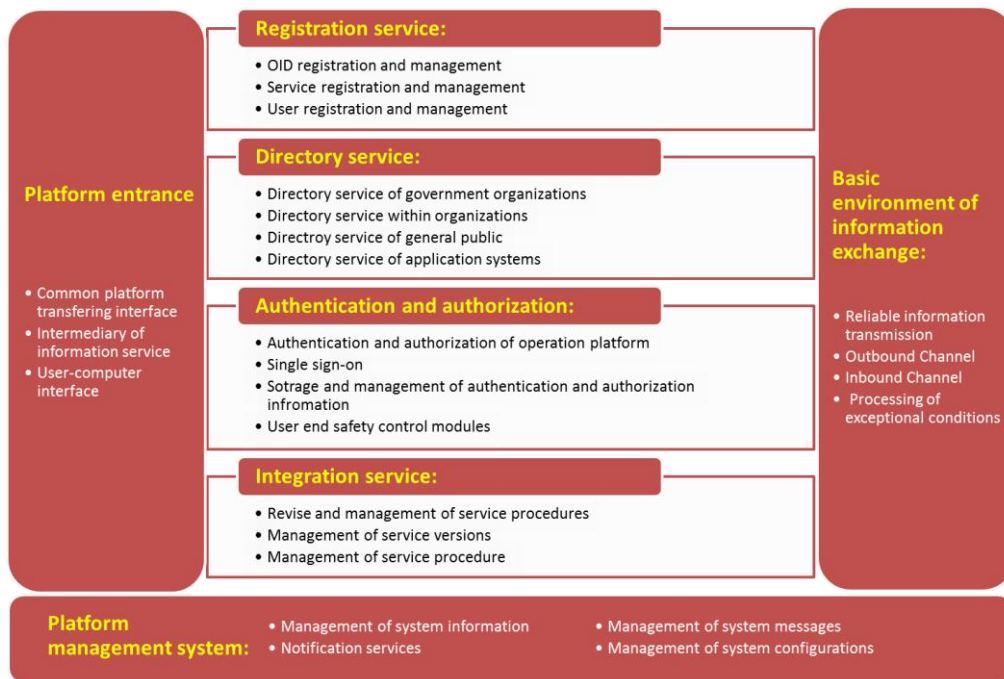


Figure 3. Functional architecture of the disaster prevention and rescue information service platform.

Strike of disasters

A typhoon may cause disasters throughout Taiwan as it approaches; thus, the government must be aware of the disasters occurring around Taiwan. Previously, the conditions were mostly compiled by first-line rescue personnel or reported by the public. However, the conditions of rural areas were unknown because people were unable to reach these areas. Therefore, in addition to the existing disaster reporting information, the platform also includes spatial telemetry technologies, which detect the disaster scale when the weather conditions permit.

Operation managements

The related information described must be provided promptly to response personnel for subsequent operations, such as evacuation, sheltering, and staff and equipment management.

This disaster response information requires disaster-related information, such as basic, historical, modeling, real-time monitoring, telemetry image, and disaster resources information. Different units manage this information under the government’s division of responsibilities. The Center performs information interworking through the service application platform of disaster prevention and rescue to enable response personnel to quickly manage related information, ensuring the information influences disaster prevention and rescue through information sharing.

The functional architecture of the service

application platform of disaster prevention and rescue (Figure 3) is divided into six main blocks:

- (1) **Platform entrance:** Platform entrance provides a single-service entrance to facilitate the integration of each module of the service platform; the entrance contains a transformation function that transforms the web service interface into an internal module interface of the platform to enhance the operation efficiency. The entrance also provides a form overlay of a user-computer interface to simplify the generation and maintenance of the user interface form.
- (2) **Registration service:** The registration service is a basic item required for complex cooperation in platform services. Operations of disaster prevention and rescue systems involve numerous users (disaster prevention and rescue personnel, ministerial officials, and the public); thus, the registration service formulates and provides a set of registration and management mechanisms to permit the system to centralize the registration and management of users and services.
- (3) **Directory service:** The directory service stores all registration and authorization information on the platform to synchronize the information of the organization. This directory is synchronized with the Government Directory Service (GDS) through the synchronization mechanism. The directory service information includes items such as the object identifiers (OID) of the public, organizations, services, and the government.



- (4) **Authentication and authorization:** ID/passwords and vouchers issued by the Government Public Key Infrastructure (GPKI) are used for authentication, including natural person certificates, organization vouchers, and industrial and commercial vouchers. Challenge-response authentication is used to confirm the identification of certificate and voucher holders.
- (5) **The basic environment of information exchange:** The information exchange processes various internal and external information exchange channels.
- (6) **Platform management system:** Management and notification services of system information, configurations, and information.

The Center has successively established a registration service, authentication and authorization, and the basic environment for information exchange of the platform, which contains approximately 40 pieces of real-time information of nearly 10 disaster prevention and rescue units, to share information of the ministerial departments. Regarding the basic image data, physical data warehouses are established considering the necessity of a stable provision of disaster response information. Related information has been progressively applied in disaster response systems to be used as a reference for decision-making by the Natural Disaster Prevention and Protection Commission. Furthermore, the platform functions are expanded to increase the information and allow all units participating in disaster prevention and rescue the prompt acquisition and sharing of related image data.

Disaster Response and Decision-Making Support System

The major purpose of establishing a disaster prevention and rescue applied information service platform is to combine disaster prevention and rescue information and facilitate the rapid sharing of image data among involved units. Once the image data was integrated, the Center also developed an assistance system for disaster-related decision-making last year to help decision-makers quickly comprehend the implications of each information piece. The purpose of the assistance system is to provide information relevant to disasters or decision-making according to the different conditions at the early, middle, and late stages of a disaster for decision-makers at disaster response centers. The disaster information display emphasizes timeliness, correctness, obtaining disaster-related information within a limited timeframe, and displaying the processed information through a webpage system interface. The displayed content focuses on information that assists in decision-making.

Consider the occurrence of typhoons for example, to analyze and monitor the effects of typhoons on Taiwan around-the-clock, the system can follow the typhoon development using the path and cloud map analysis conducted by the Central Weather Bureau as soon as typhoons form. As typhoons approach Taiwan, the system can successively provide early warning information through analysis of the weather, flooding, and slopes. Because typhoons cause disasters, the disaster situation can be understood promptly using the system; the application procedure is shown in Figure 4.

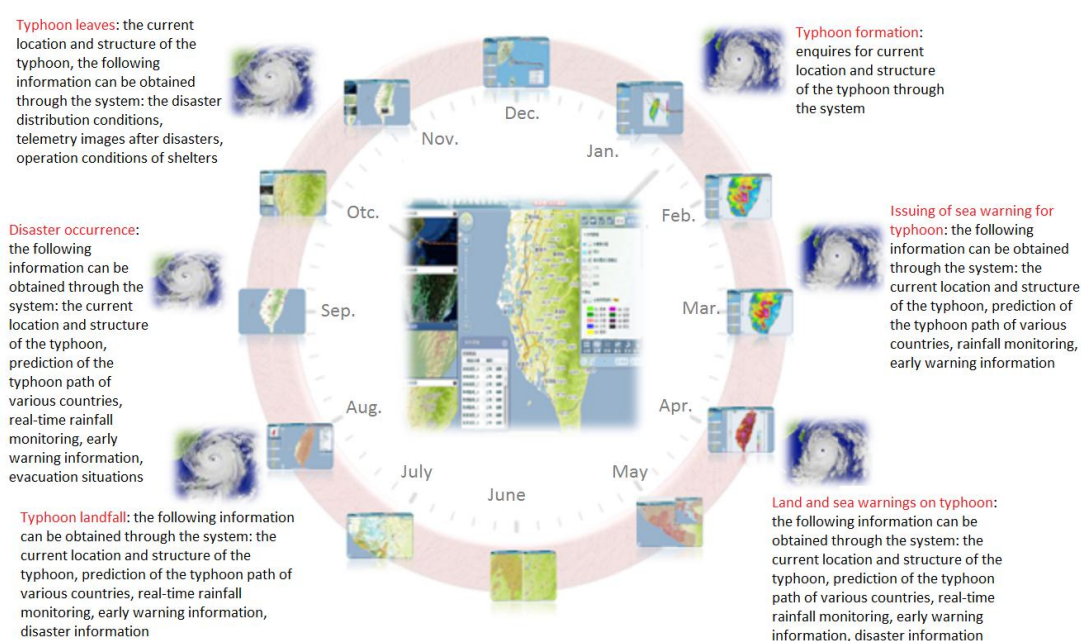


Figure 4. Flowchart of typhoon disaster system applications.



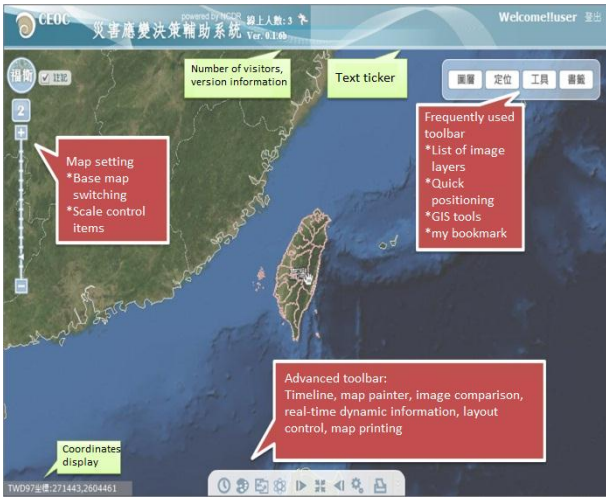


Figure 5. Design of the system interface.

The system design emphasizes the requirements of each unit of the disaster response centers, with simplicity being the design concept. The interface control block is divided into three portions. The first portion is “map setting,” which includes the base map and scale switches on the upper left of the interface; the second portion is “frequently used toolbar,” which includes image layers, positioning, tools, and bookmarks displayed in the largest block on the upper right corner of the interface; users can change the tools by clicking on the mouse. The toolbar of this interface can be moved to any location within the system. Finally, the “advance toolbar” is centered on the bottom of the interface and includes real-time dynamic information, image comparison function, timeline function, map painter, screen setting, and map printing; it provides users with interface functions when activated. The relevant images are shown in Figure 5.

The disaster response decision-making assistance system currently uses the real-time information provided by the service application platform of disaster prevention and rescue. The information is value-added and integrated to provide graphical disaster information; it can be manipulated to obtain required disaster information according to various response stages to solve the problem of spatial overlaying because of different information sources, ultimately improving the efficiency of disaster responses.

The system can be separated into three conditions according to the following typhoon features: sea warning for typhoon (typhoon may strike), land and sea warning (typhoon approaches), and disaster occurrence. The time segment for each condition was determined by the typhoon early warning information issued by the Central Weather Bureau. The conditions are further divided into the following four situations according to the requirements of the disaster response.



Figure 6. Prediction of typhoon paths.

Typhoon dynamics and disaster prediction

When issuing warnings for typhoons approaching the waters near Taiwan, the Central Weather Bureau must analyze the situation according to the forecast data available. The system provides personnel at response centers preliminary typhoon information and future predictive information, as shown in Figure 6.

Collection of dynamic monitoring information

The system obtains monitored disaster information through the Internet, and, considering the requirements for assistance in disaster response decision-making, the added-value of each monitored information piece displayed in the system must be applied to strengthen the function of early disaster warnings. Related monitored information, such as real-time rainfall and the water level of rivers and reservoirs, are shown in Figure 7.

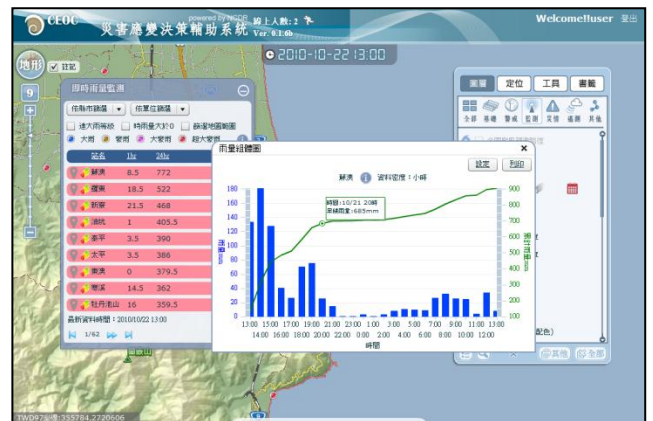


Figure 7. Dynamic real-time rainfall monitoring.



Figure 8. Flood warning areas.

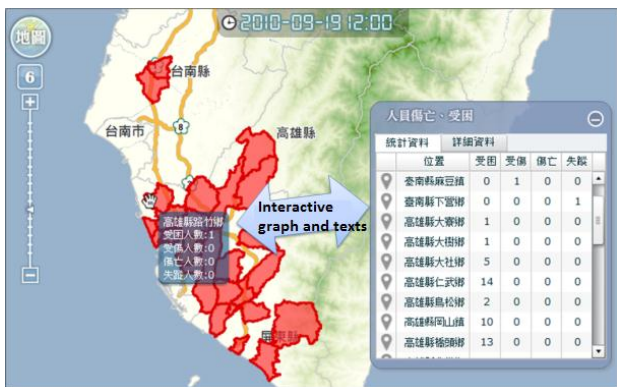


Figure 9. Real-time information of disaster situations.

Early warning

To assist decision-makers in responding to disasters, the system is designed to display the integrated information of each analyzed early warning model, such as flood warning areas and hazardous slope areas, on the screen before disasters occur (Figure 8).

Compilation of disaster situations

As typhoons or earthquakes occur, the real-time disaster portion of the system can be reported through disaster response centers in each area or through other channels. The types of disaster situation can be classified into casualties, trapped, or flooded areas. The recording unit at the Central rapid report information is based on administrative unit to record the number of people evacuated or persuaded to evacuate, statistics on evacuation shelter establishment, and statistics on disaster relief supply distribution (Figure 9).

Disaster information is complex and encompasses a wide variety; thus, maintaining the information in real-time presents a major challenge. The follow-up aims are to establish a more comprehensive mechanism for monitoring information conditions to ensure the information quality. Additionally, because of the wide variety of information and an urgent need for information during disaster response periods, the system

focuses on the overall system architecture, makes flexible background designs, and plans open disaster responding image bases to meet the needs of disaster responses.

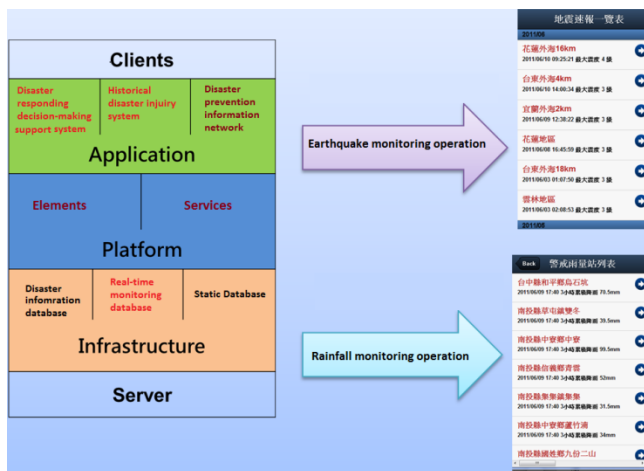


Figure 10. Automatic mobile message mechanism.

Automatic Mobile Message Reporting Systems

The disaster prevention and rescue application platform has been progressively integrated with the real-time monitoring information of each unit. The Center initiated the establishment of an automatic mobile reporting system to enable the relevant monitored information to perform its function of providing a real-time early warning (Figure 10). Rainfall alerts and earthquake notifications are the primary targets in the initial stage. This allows users to understand the situation through mobile devices, such as mobile phones, for the first time.

The operations of rainfall and earthquake report systems are introduced below.

Automatic rainfall alert messaging system

Most of the natural disasters occurring in Taiwan are caused by an overaccumulation of rainfall. For example, flooding is caused by large amounts of unvented rainfall, and debris flows are induced by exceeding moisture content of soil. Therefore, the monitored rainfall accumulation information can be provided to related personnel for issuing early warnings to prevent unnecessary losses. The rainfall messaging system was developed based on this concept. The system analyzes the rainfall information received from the Central Weather Bureau every 10 min, and automatically sends warnings if the rainfall accumulation exceeds the threshold. Users may also inquire the rainfall distribution, location, and rainfall values through the mobile Internet access function of smart phones.

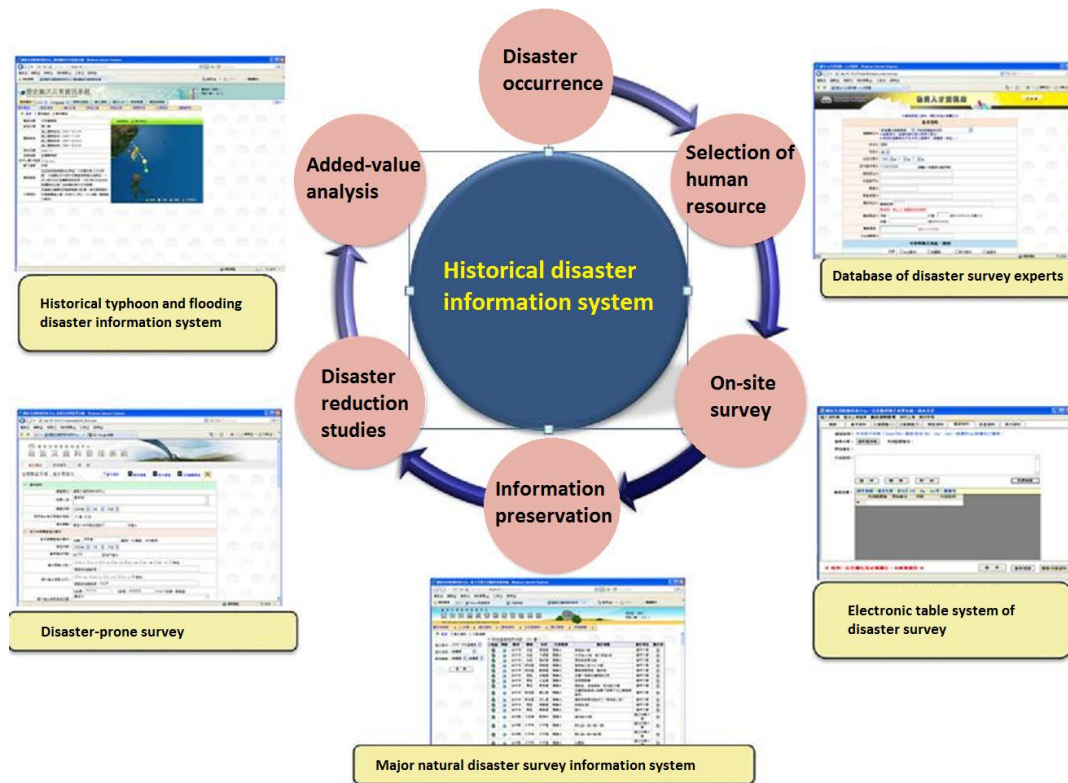


Figure 11. The timing for using each type of information.

Automatic earthquake alert messaging system

Current technologies are unable to predict the time and scale of earthquake occurrences; therefore, mastering the time, location, and scale of an earthquake as it occurs is crucial. The purpose of developing the automatic earthquake alert messaging system is to understand the affected range and major facilities of each area by quickly evaluating the epicenter and scale of an earthquake as it occurs. This will enable response personnel to quickly understand the affected areas through the messages. In addition to messages, users may also inquire the scales and locations of historical earthquakes using the system to determine whether a correlation exists between the current earthquake and previous earthquakes.

Historical Disaster Information System

After Typhoon Mindulle in 2004, and the 0702 heavy rain, the Center developed a historical disaster information system to effectively preserve and more efficiently collect, analyze, and add value to disaster information. The information collected in the historical disaster information system includes the following: historical disasters, disaster-prone area information, disaster survey information, database of disaster survey experts, and major typhoons and flooding over the last

10 years. The timing for using each information type is shown in Figure 11.

Comprehensive and detailed disaster information of various disaster surveys requires a large amount of human resources; thus, the Center engages local collaborative teams to report on-site survey information, such as disaster-proneness and disaster surveys, using the historical disaster information system. The related functions from reporting, reviewing, and to inquiry work smoothly, enabling more efficient collection of disaster information. Concurrently, with the advancements in geographical information technologies, the geographic image data reported by collaborative teams can be displayed on the functional interface, transforming the text-only disaster information into geographic spatial information with visual effects. The mechanism of the automatic disaster survey recording procedure is shown in Figure 12.

Additionally, for added-value information, the Center combines disaster survey information with the survey information of the ministerial government departments into historical disaster information; information of disaster-prone areas is compiled into a disaster-proneness atlas. The Center is also working to systemize the added-value project to enable personnel to quickly compile historical disaster information and automatically produce atlases through geographical information technologies.

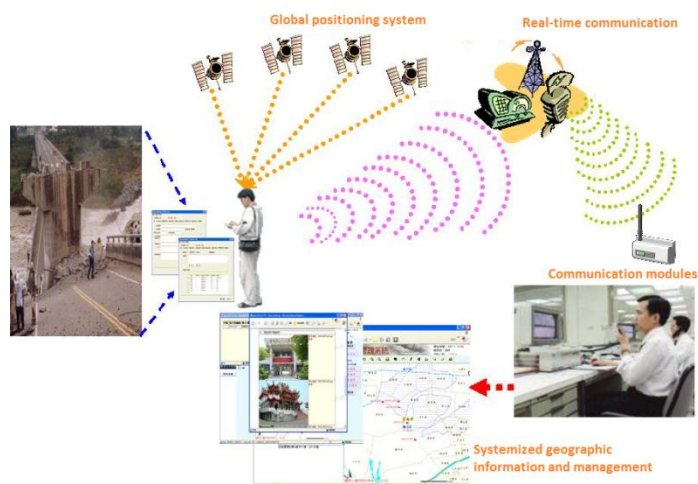


Figure 12. Mechanism of the automatic disaster survey recording procedure.

Various historical disaster information systems, such as the disaster response decision-making support system and universal geographical information system, are provided concurrently in the system developed by the Center. Each information system can display and obtain disaster information synchronously to integrate and share information.

Conclusion

The Center adopted disaster response as its primary focus, and established a service application platform of disaster prevention and rescue to integrate disaster response image data. For example, the image data and the automatic integration added-value of real-time images generated by the disaster response assistance system enable decision-makers of the Central Emergency Operation Center to understand the real-time disaster conditions throughout the disaster response process. Specialized staff can also comprehend the rainfall and earthquake conditions through the mobile message reporting system. Historical disaster information systems can quickly compile the image data of on-site surveys after the disaster as references for later applications. Extensions of the application platform are effective for disaster management.

The purpose of establishing the service application platform of disaster prevention and rescue is to share disaster prevention and rescue image data. Therefore, the platform will continue to increase the development of relevant image data services and the construction of platform information networks that enable personnel from each response unit to conveniently and rapidly obtain relevant image data.

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