Sediment Disaster Notification System Established for the Reservoirs in Southern Taiwan

Tsai-Tsung TSAI[1,2*], Kuang-Jung TSAI[3], Chjeng-Lun SHIEH[1,2] and Yie-Ruey CHEN[3]

[1] Disaster Prevention Education Center, National Cheng Kung University
(No.1, University Road, Tainan City 701, Taiwan R.O.C.)
[2] Department of Hydraulic and Ocean Engineering, National Cheng Kung University
(No.1, University Road, Tainan City 701, Taiwan R.O.C.)
[3] Department of Land Management and Development, Chang Jung Christian University
(No.1, Changda Road, Gueiren District, Tainan City 71101, Taiwan R.O.C.)
*Corresponding author. E-mail: victor@dprc.ncku.edu.tw

Typhoon Morakot struck Taiwan in 8th August 2009. It brought astonishing rainfall and caused extreme sediment disasters. This event awakens the public awareness of sediment disasters. Over the past few years, this study has devoted much resources constructing the Sediment Disaster Database of the reservoirs in southern Taiwan. The SDDB is currently available to assist the reservoirs managers quickly invoke the archiving environment data. To further assist the reservoir management issues, this study is now focusing on the establishment of Sediment Disaster Notification System to assist reservoir managers improving the grasp of the situation of sediment disasters in reservoir catchment.

Key words: Sediment Disaster Notification System, Standardization Specification for Data, HTML5

1. ORIGIN

In 8th August 2009, typhoon Morakot struck southern Taiwan and brought more than 2,900 mm accumulated rainfall within 4 days. Some extreme serious sediment disasters such as landslide and debris flows were induced by this event, for example, Nantou Branch, SWCB (2010) mentioned there were more than 10,904 sites of landslide with total sliding area of 18,113 ha occurred in Zengwen reservoir watershed after typhoon Morakot. This event awakens the public awareness of sediment disasters. Sediment disasters have negative effects on the operating functions of reservoirs. Base on the formats and characteristics of sediment disasters, here are some issues must be conquered:

(a) The trigger mechanism of large scale compound sediment disaster under extreme rainfall condition.
(b) The establishment of disaster prevention database and the revise of disaster prevention strategy.
(c) The predominance of sediment disasters information and status.
(d) The strategy and measure for disaster prevention, reducing and mitigation.

After these issues were conquered, the disaster resistance of reservoir catchment will be enhanced, the land conservation will be ensured, the reservoir development will be sustained, and most important is the water supply in southern Taiwan will be stable. To decrease the risk of these disasters within reservoir watershed, the establishment of a powerful tool for hazard mitigation / disaster prevention is necessary. In previous phase basic environment data was collected for establishing the Sediment Disaster Database (SDDB). In following phase, the establishment of Sediment Disaster Notification System (SDNS) to assist reservoir managers improving the grasp of the situation of sediment disasters in reservoir catchment will become the most important issue.

2. THE ESTABLISHMENT OF SEDIMENT DISASTER NOTIFICATION SYSTEM

In the premise of user friendly, the SDNS is developed based on the SDDB, and applied with the new generation technical protocols. Here is some information about this system.

2.1 Request analysis

Request analysis is the most important work before system construction. **Fig. 1** is the result. There were two main issue shown, "immediate disaster notification" and "decision support"

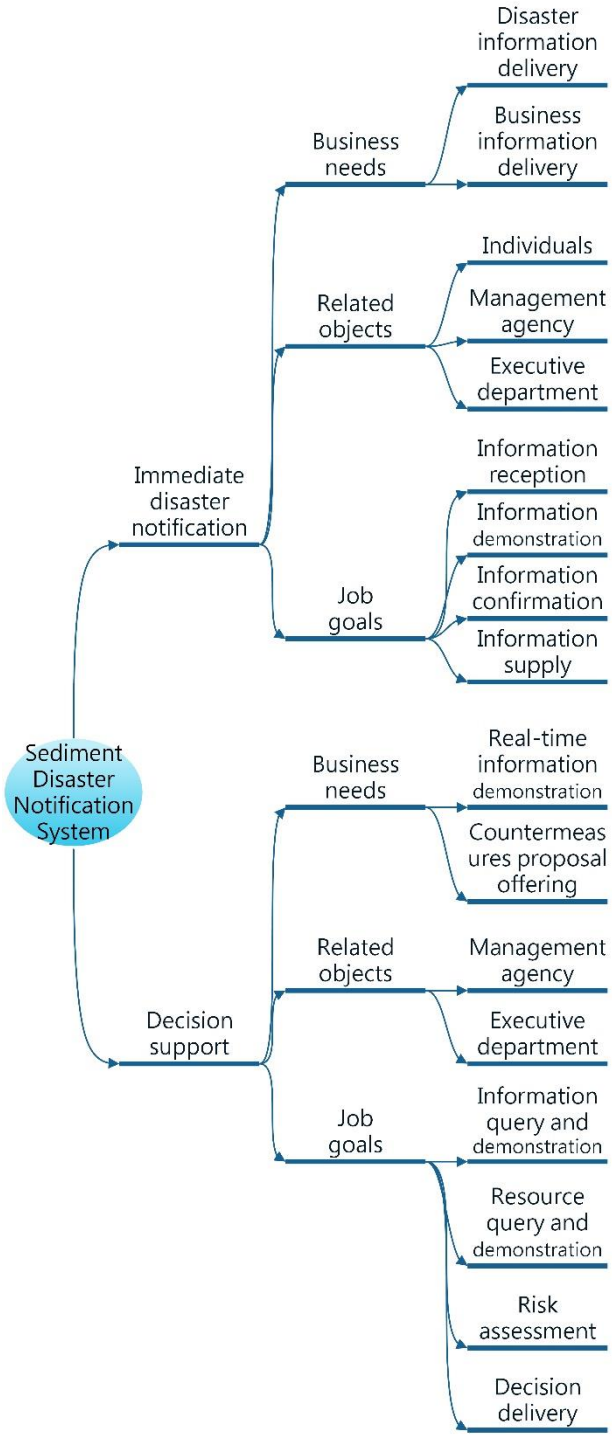

Fig. 1 Request analysis result

2.1.1 Immediate disaster notification

Disaster information delivery and business information delivery are the needs of this issue, individuals, management agency and executive department are related objects, reception, demonstration, confirmation, and supply of information are the goals of jobs. As **Fig. 2** shown, follow the concept of immediate disaster notification, there are many information streams should be delivered between individuals, management agency and executive department, to make every kind of information have been well known.

2.1.2 Decision support

Real-time information demonstration and countermeasures proposal offering are the needs of this issue, management agency and executive department are related objects, information/resource query and demonstration, risk assessment, and decision delivery are the goals of jobs. As **Fig. 3** shown, follow the concept of decision support, those primarily connection of information was between management agency and executive departments. Only partially controlled public information will be provided to individuals.

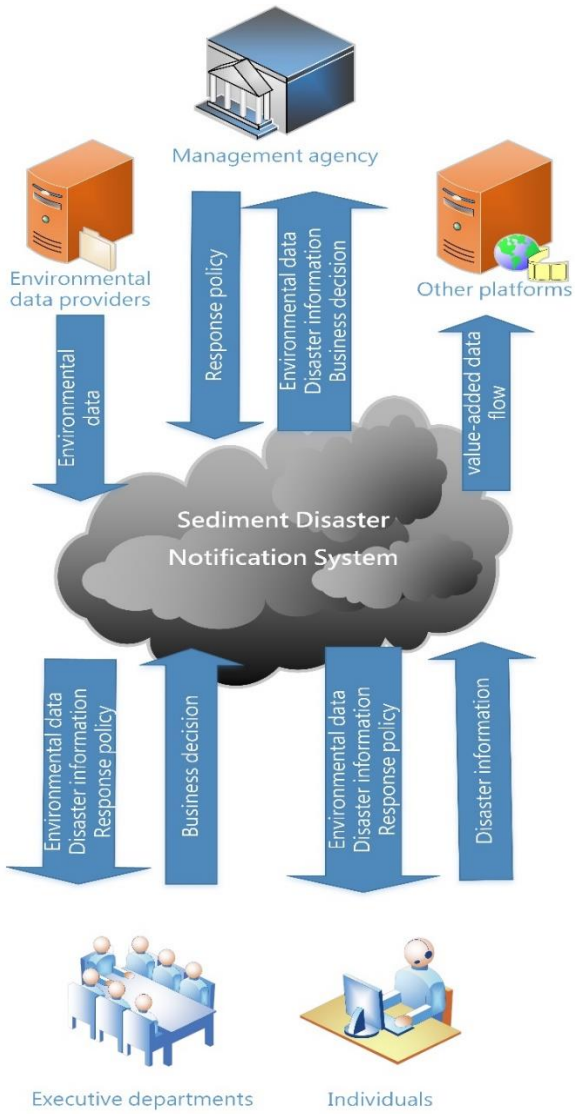

Fig. 2 concept of immediate disaster notification

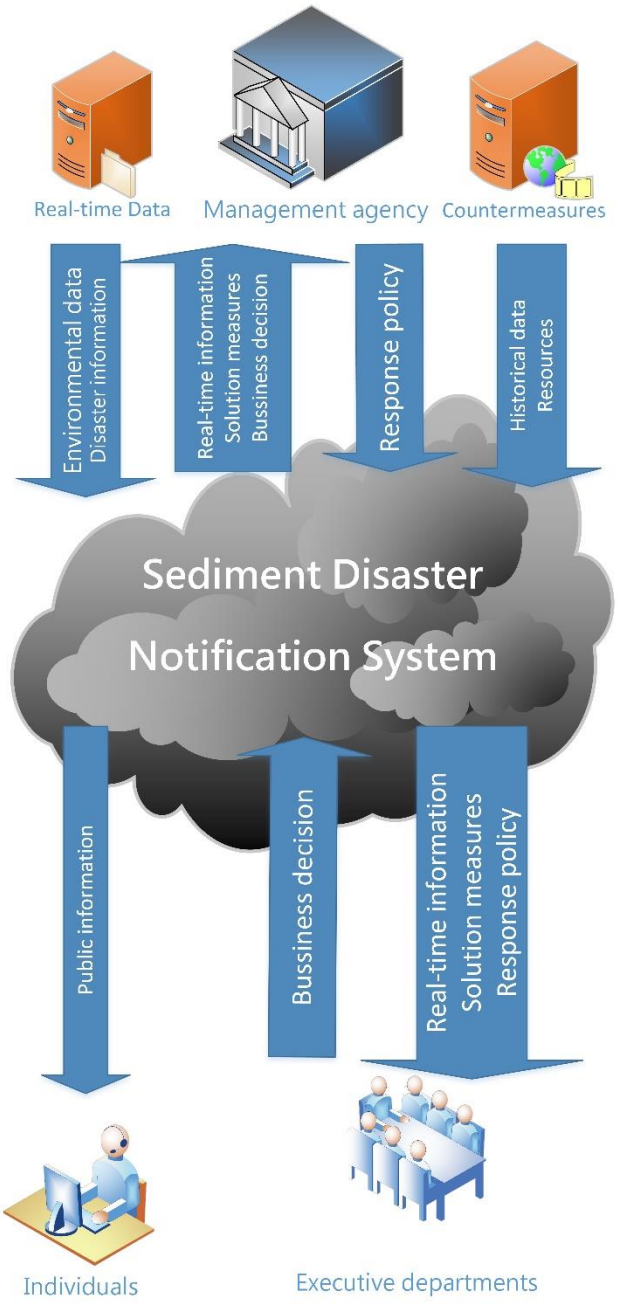

Fig. 3 concept of decision support

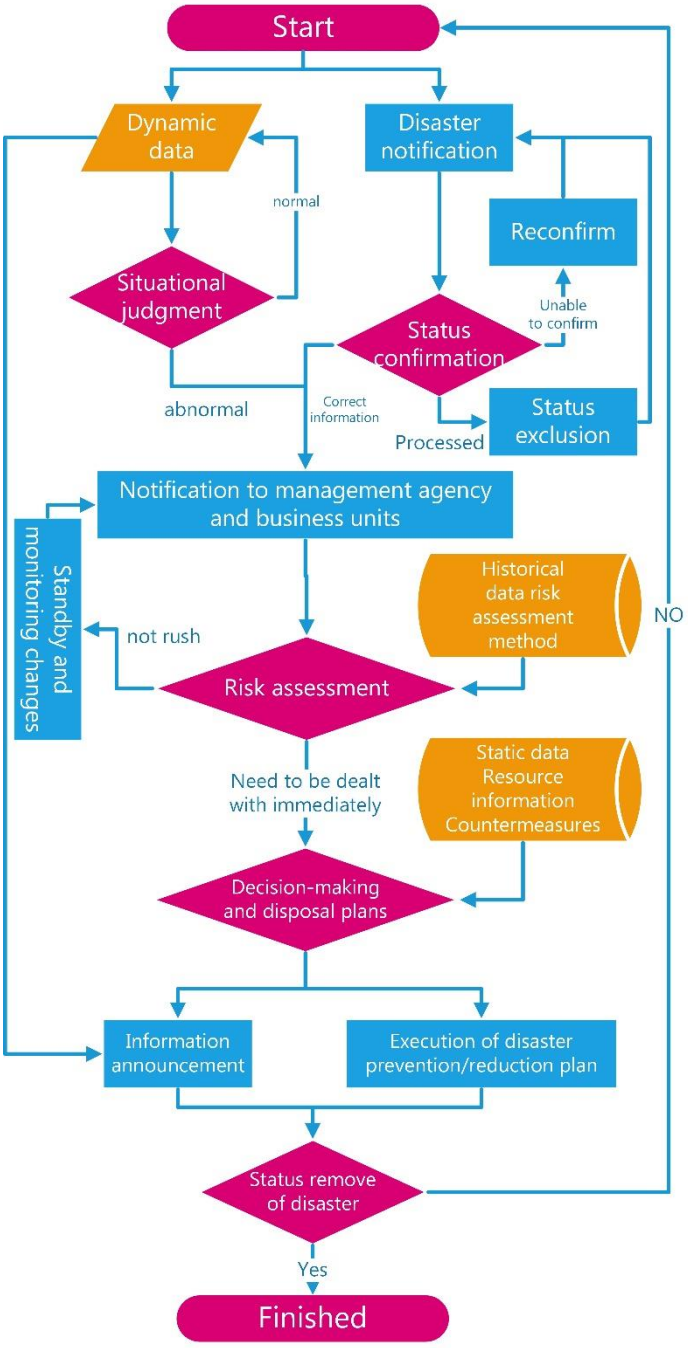

Fig. 4 Workflow of the SDNS

2.2 System analysis

After the request analysis, the requirements for SDNS could be grasped, system analysis is needed to be executed before system design.

As **Fig. 4** Shown, at the beginning of the assignment, the near-real-time environment data will be imported automatically form the data source, the situational analysis will be conducted at the same time to confirm the status of target area is normal or abnormal. These processes will be continued for normal situation cases. If the result of the judgment is abnormal, next procedure will be preceded, the management agency and the business units will be notified.

Meanwhile, the system also started receiving the notifications of disasters. All disaster information should be confirmed. That disaster information cannot be confirmed would not be imported but will be returned to the notification mechanism for confirmation; If the confirmed disaster information is the first report or is an update, the details will be moved to the next step, to notify the management agency and the business unit. However, if the disaster information received has been notified and there is no state change, it will be excluded from entering the notification procedure.

When the management agency and the business unit receive the notification, the risk assessment process will be started. Meanwhile, in addition to the existing dynamic data and disaster information, it is also necessary to retrieve historical disaster data with similar situation from the database for risk assessment. If the result of the assessment is not necessary for immediate processing, the record shall be placed on standby to pay attention to changes in its status and continue to pay attention to whether there is a new disaster. If the assessment requires immediate processing, proceed to the next stage for countermeasure development.

After entering the strategy development stage, the static data should be retrieved from the database to grasp the environmental conditions of the disaster site. In addition, the relief resources should be queried to confirm the available manpower, equipment, equipment, and material distribution. The disposal methods of similar situations in the past, the rules and regulations of the relevant laws, and the response strategies for similar situations were also should be queried at the same time. To synthesize the above information, management agency and business unit can formulate decision-making and disposal plans. And based on the results, some relevant information will be announced, and some necessary disaster prevention/reduction plan will be executed. When a single disaster is disposed of, it will come back to the initial step, Import dynamic data and disaster information until the end of the event.

2.3 Technical requirements analysis

To build this system platform with the required functions mentioned, some information technology was required.

2.3.1 Data analysis technology

How to handle Big Data is the key to affect the value of data. To meet the huge amount of disaster prevention data, R language will be adopted for data analysis, statistics, and statistics charts. In the SQL Server 2016, R has been added as the latest built-in analysis tool. Calculation of large number of disaster-resilient data through the R-linked database should make advanced analysis more accessible, the efficiency of all analysis would be increased.

2.3.2 Emergency alert message

With big data, under the concept of Open Data, to make data more profitable, a standard for information collaboration is needed. The Disaster Warning Public Information Platform (https://alerts.ncdr.nat.gov.tw/) shows very good example. The Common Alerting Protocol (CAP) of the "Common Alerting Agreement" was adopted. It is an international common standard agreement for data conversion technology consistency (current version is 1.2) used between different network platforms for exchanging communication data in emergency disaster situation. The purpose is to adopt an open, non-proprietary digital message format, and does not restrict any specific application or communication method to provide all types of alerts, warning notices. Therefore, the use of CAP can reduce the system design cost and complexity of operation. It can be used to customize various disaster warning messages in various media.

2.3.3 Platform service interface

The current information and communication technologies are on the fast track, and the media that can be used are also more diversified. Considering the conditions that will be faced, the actual usage of the platform, different devices such as desktop computers, notebook computers, tablet computers, smart mobile phones, etc. would be used, also consider the balancing of convenience, efficiency, user's convenience and efficiency. Under these limitation, for providing the best experience, while reducing the impact from software or operating environment. Therefore, those tools that have met the mainstream information protocols were chosen for the development of the SDNS service interface. After evaluating the user's operation fluency, reducing network traffic, and high browser support, HTML5, Angular.js, and jQuery will be used as the core tools for development.

2.3.4 Map service interface

This system aims to reduce the threshold for user operation and provide the best operating experience. After the evaluation, Google Map is used as the basic map platform, and the Google Map API and JavaScript suite D3.js are used to display the environment and resources. The format of kml, kmz, etc. were used as the main data format in this system, to facilitate the display of various types of data such as disaster prevention resources, rivers, rainfall stations, disaster spots, etc., and improve the convenience of query, operation and immediate efficiency.

2.4 System architecture

According to the requirements mentioned above, the architecture of the system is as **Fig. 5**.

2.4.1 Dynamic database

The dynamic database is mainly used to process and store real-time data of disaster incidents. To import and process external data, data import module and value-added module were needed to be established.

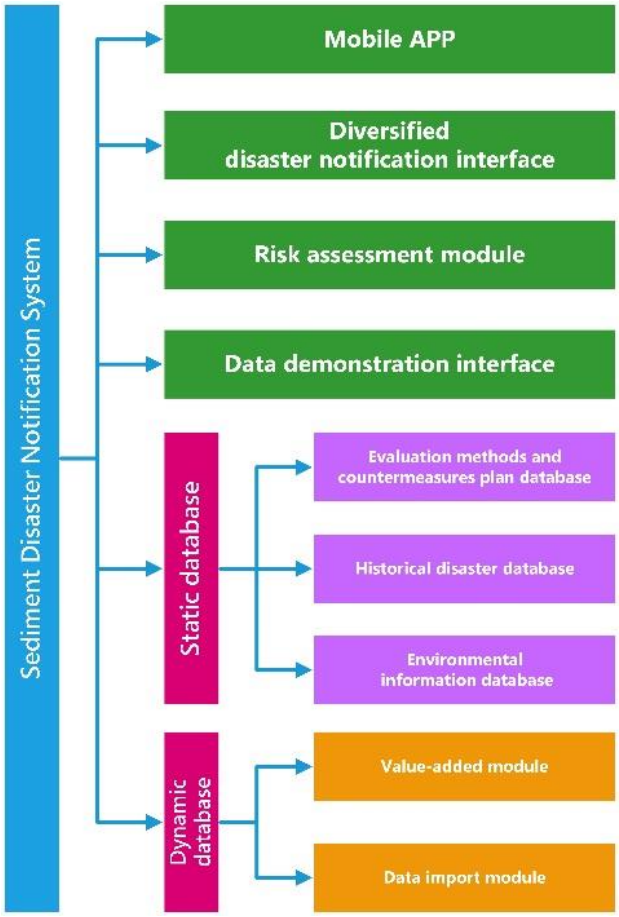

Fig. 5 System architecture of the SDNS

2.4.2 Static database

The static data base is mainly used to store all types of basic information needed for the operation of the pure platform. It can be divided into environmental information database, historical disaster database, evaluation methods and countermeasures plan database.

(a) Environmental information database:
The contents of the environmental information database mainly include information on administrative areas, traffic network, water systems, historical disaster sites, potential disaster areas, and so on.

(b) Historical disaster database:
Historical disaster database content is information related to past disaster events. It mainly includes information such as the event overview, location, time, type of disaster, scale of disaster, loss status, and disposal methods.

(c) Evaluation methods and countermeasures plan database:
The contents of the evaluation methods and countermeasures plan database mainly including various disaster risk assessment methods, possible scenarios, response strategies, and other information built on the platform for reference.

2.4.3 Data demonstration interface

The data demonstration interface is mainly used to demonstrate various dynamic information, the distribution of disasters, and the information that the management agency and the business unit released to the public.

2.4.4 Risk assessment module

The risk assessment module is a tool that compares the situations built in the platform database with dynamic data or user-defined conditions, to provide tools and countermeasures for the management agency and the business unit.

2.4.5 Diversified disaster notification interface

The diversified disaster notification interface enables the users to provide disaster information interfaces in various ways, including voice, SMS, fax, and mobile APP..., which is the main channel for the platform to exchange disaster information.

2.4.6 Mobile APP

The Mobile App is an action tool that is based on the needs of the platform to obtain disaster information and is designed to reduce the complexity of the operation of the public. It is also an important channel for the platform to directly push important information from the management agency and the business unit to the public.

2.5 System functions and goals

The SDNS is not traditional Management Information System (MIS) or Geographic Information System (GIS), is a system based on user friendly concept and considerate about the business needs of reservoir managers, the scalability of system structure, and the safety of information exchange, the main system functions and goals are:

2.5.1 To deliver the disaster information to managers.

Grasping the correct real-time situation is the most important issue for managers. Especially during the disaster process, the decision-making of manpower dispatching, resource dispatching, and personnel placement all relied on the correct disaster information. The functions of information delivering, receiving, and confirming should be built in SDNS.

2.5.2 To collect complete environment information of disaster regions.

To build a comprehensive system, each kind information about the study area should be digitized and imported into system database. Although some data has been built in the SDDB, the works of data collecting should be continued. Meanwhile, SDDB data format standard should be followed, all archive documents should be kept in two forms, one is the

original file format made by professional software, the other one is the pre-defined portable document format.

2.5.3 To establish convenient interface for query and management.

For efficiency usages for both data query and study area management user-friendly interfaces are necessary to be established. These interfaces should be provided in the easiest way for users to get information they want and feedback useful information to system. In this study there are 4 types of interfaces should be established, included system management interface, real-time data demonstration interface, disaster information exchange interface, and mobile device application interface.

2.5.4 To enhance the security of data access.

In the trend of "Big Data" and "Open Data", the achievements of database will be utilized cross-sectorally, even will be opened to public. For the balancing between "Open Data" and "information security", the "three–tier" structure was used. Data will not be contacted directly by users; all requests will be delivered through interfaces and be authorized by the interface. All system responses will also be delivered through the same interfaces.

2.5.5 To improve the efficiency of catchment management.

In the premise of user friendly and management efficiency, the mobilized needs were also considered. To provide more flexible interface, HTML5 standard was followed, meanwhile, Responsive Web Design (RWD) was used with. This means users could easily get the same use experience using this system in any kind of device and would not have to install any special plugins.

2.6 Standardization specification for data

Base on the experience from establishing SDDB, four basic data types were pre-defined, for reducing the complexity of data process and for enhancing the efficiency of data exchange.

2.6.1 General documents

- Definition:
  General software output, data file contains text, pictures, figures, or tables.
- Demonstration format:
  Portable Document Format (PDF), *.pdf.
- Archive format:
  *.pdf.
- Original formats:
  Common file types include plain text files (*.txt), Word files (*.doc, *.docx), Excel files (*.xls, *.xlsx), presentation files (*.ppt, *.pptx) Portable Document (*.pdf) ... and so on.

2.6.2 Graphics file

- Definition:
  A data file presented in a Raster format.
- Demonstration format:
  Joint Photographic Experts Group (Joint Photographic Experts Group, JPEG) format, *. jpg.
- Archive format:
  *. jpg.
- Original formats:
  Common file types include image files (*.jpg, *.png, *.bmp, *.tiff, *.img), AutoCAD files (*.dwg).

2.6.3 Geographic information file

- Definition:
  A data file presented in a Vector format.
- Demonstration format:
  Joint Photographic Experts Group (JPEG) format, *. jpg.
- Archive format:
  Keyhole Markup Language (KML) format, *. kml.
- Original formats:
  Common file types include Shapefile (*.shp), track file (*.kml).

2.6.4 Multimedia file

- Definition:
  A data file made up of audio, video, or audio and video.
- Demonstration format:
  Moving Picture Experts Group-4 Part 10 Advanced Video Coding (MPEG-4 AVC) format, *.mp4.
- Archive format:
  *.mp4.
- Original formats:
  Common file types include audio and video files (*.avi, *.mpg, *.Mp4), QuickTime ring file (*.mov), three-dimensional nested engineering environment project (*. sxd).

The flexibility of system architecture and standardization specification was reserved, the new data types and formats will be easily declared the definition by system administrator when there were some new data categories or formats will be used in this system in the future.

3. STAGE RESULTS

The SDNS is still under construction, core database come from SDDB was already re-processed to meet the needs of SDNS. Basic data request and feedback functions were done. In this stage, dynamic database and data demonstration

interface are ready, **Fig. 6** and **Fig. 7** show real-time data demonstrated on the system interface.

The notification functions such as voice message, SMS (**Fig. 8**), MMS, and FAX (**Fig. 9**) are ready now.

The mobile APP in under construction, partial functions have been completed (**Fig. 10~ Fig. 11**), the corresponding control interface of the system is still under development.

The follow-up will be the user interface optimization and testing phase.

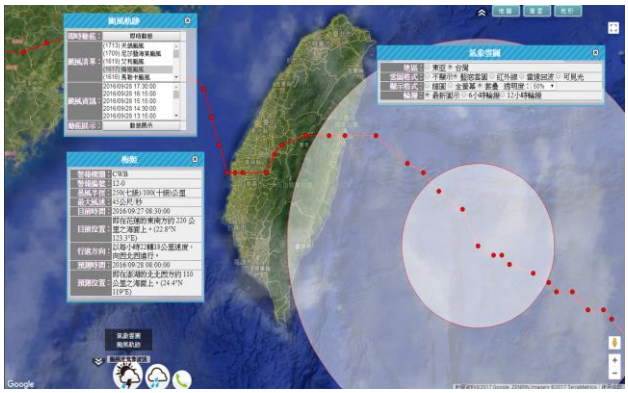

Fig. 6 Real-time typhoon data demonstrate on SDNS

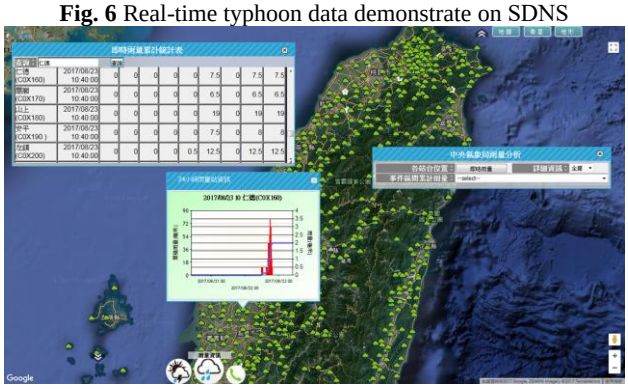

Fig. 7 Real-time rainfall data demonstrate on SDNS

Fig. 8 SMS interface on SDNS

Fig. 9 Fax interface on SDNS

Fig. 10 Data collection interface of mobile APP

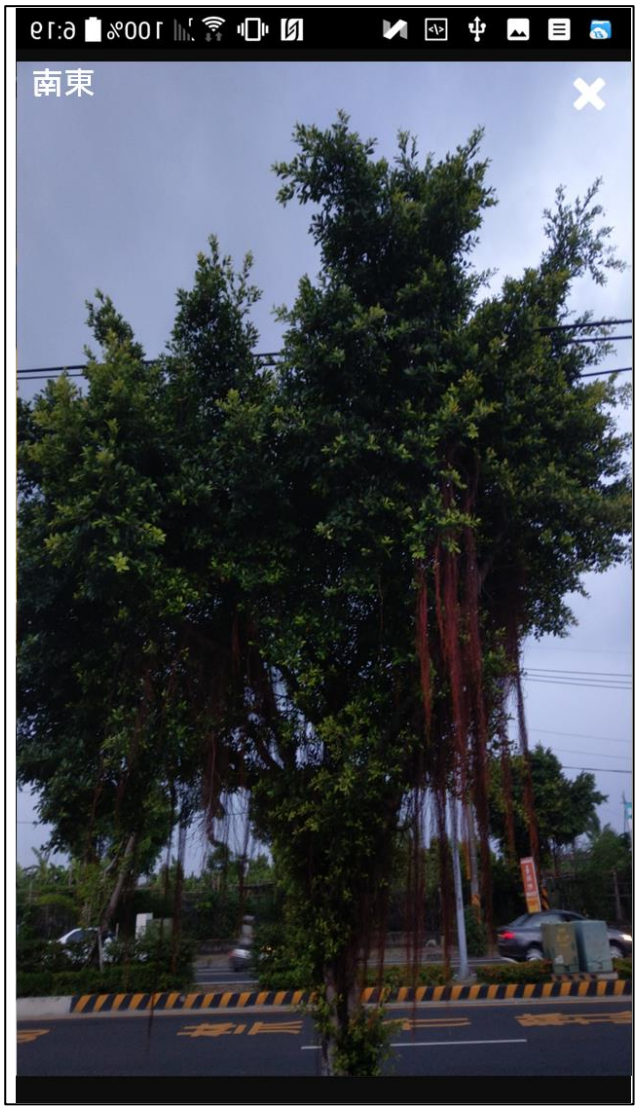

Fig. 11 Photo editing interface of mobile APP

4. CONCLUSIONS

To assist reservoir managers improving the grasp of the situation of sediment disasters in reservoir catchment, the development of SDNS was started. In the "Origin" part of this article mentioned there were four important issues must to be conquered, SNDS was based on the SDDB which built-in information for issue (b) and was designed with quick information exchange functions for issues (c) and (d). Although the establishment of SDNS is ongoing, users already can easily request archive data or documents now. Those achievement have been pre-processed with the "standardization specification for data", it means users need to do nothing but access the achievements directly. The notification feature will provide users with a more convenient way to publish or get disaster information. This will bring benefits on manpower saving and improve the performance on the management of sediment disasters in reservoir catchment.

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REFERENCES

Nantou Branch, Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan (2010): The overall rehabilitation plan for the Morakot disaster in the upper catchment of Zengwen River, Report of the Soil and Water Conservation Bureau of the Agricultural Committee of the Executive Yuan.

Kuang-Jung Tsai et al. (2010): Development and application of the governance and engineering management information system for the Zengwen reservoir catchment, Journal of Sinotech Engineering, Vol.106, pp. 73-78.

Kuang-Jung Tsai et al. (2014): Investigation and analysis of the variability of hydrological and geochemical environment in the Gaoping River watershed under extreme climate change, Journal of Mining & Metallurgy, Vol.58, No. 1, pp.45-61.

Chjeng-Lun Shieh et al. (2010): Landslide interpretation of Typhoon Morakot using the Formosat-II imagery, Journal of the Taiwan Disaster Prevention Society, Vol. 2, No. 1, pp.35-42.

Charlton R. el al. (2006) Assessing the impact of climate change on water supply and flood hazard in Ireland using statistical downscaling and hydrological modeling techniques, Climate Change, Vol. 74, pp. 475-491.

Yie-Ruey Chen, Po-Ning NI, Kuang-Jung Tsai (2013) Construction of a sediment disaster risk assessment model, Environ Earth Sci (2013)70,pp.115-129. (SCI, IF:1.425)

Jones R. N.(2001) An Environmental Risk Assessment/Management Framework for Climate Change Impact Assessments, Natural Hazards, Vol.23, pp.197-230.

Kuang-Jung Tsai, Yie-Ruey Chen, Shun-Chieh Hsieh, Chia-Chun Shu, Ying-Hui Chen(2014) An Establishment of Rainfall-induced Soil Erosion Index for the Slope Land in Watershed, European Geosciences Union General Assembly 2014, Apr. 2014, Vienna, Austria.