One of the Nowcasting Applications: Early Warning Systems for Natural Disasters in Korea

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I. Introduction

From 1995 to 2004 in Korea, an annual average of 131 people lost their lives, mostly because of floods and landslides caused by typhoons and torrential rains in the summer. Various systematic multi-hazard warning systems have been proposed and established to protect people's lives and minimize damage to critical infrastructures in different areas.

Some of them may be directly connected with nowcasting concept and some of them are just warning systems that Korean government is practicing. General warning sequence is about the hazard and disaster information produced, transmitted, received, understood, believed, confirmed, etc. This paper, as a disaster management point of view, is not about the generation of warning information, rather it is about how to transmit it to the public.

One of the benefits that nowcasting technology can contribute to the public is mitigating disaster damages, especially disasters caused by hydro-meteorological phenomena.

II. Warning Systems

From conventional, commercial electronic display boards to cutting-edge information technologies, six different early warning systems now operate against natural disasters in Korea: i.e. the Cell Broadcasting Service (CBS) mobile phone message system, automatic verbal notification system, automatic rainfall warning system, disaster notification board system, TV disaster warning broadcasting systems, and radio disaster warning broadcasting system using the radio data system (RDS).

1. The CBS mobile phone disaster message notification system

The CBS mobile phone disaster message notification system broadcasts disaster information to mobile phone users with a special receivable ID at the base station transceiver subsystem.

Unlike the short message service, which is a point-to-point individual transmission, the CBS system can transmit messages nationwide or to local areas, simultaneously or independently.

Serviceable telecoms companies and targeted areas were selected in November 2004, after which users' responses were analyzed and an interactive system was set up in Korea's National Emergency Management Agency (NEMA) in 2006.

So far, the system has broadcast 57 warnings to more than 19 million mobile phone users – that is, 39 for heavy snows and roadblocks, nine for wildfires, three for tsunamis, three for gusts and heavy rains, and three for drought and yellow dusts.

This system has several advantages. Information reception is possible via an equipped CBS module without additional hardware, so nationwide broadcasting is possible.

This system is suitable for real-time warning services because multi-user transmissions are available simultaneously by broadcasting characteristics. The service cost is low, independent of the number of users. Users can easily select, confirm, and delete information.

This system, however, has some weaknesses. For a start, it is terminal-oriented – without a mobile terminal or CBS module, information cannot be received. If the terminal is turned off, no information is available even with a CBS module. The reception rate is another problem. The disaster information is not available in radio-dark areas and there is no automatic confirmation method to check whether or not users have received disaster information.

2. The Automatic Verbal Notification System

The second system for early warning is the automatic verbal notification system. Automatic voice notification equipment located at the local disaster management headquarters can issue warnings using fixed or mobile telephones, village broadcast amplifiers and any available communication tools when inundation and other disasters are imminent.

When rain precipitation, river level, or any emergency data in a specific area are analyzed, persons to be informed are chosen and a disaster warning is issued using 32 exclusive emergency communication networks. The system database covers more than 550,000 people such as emergency managers and local residents in 234 central and regional districts.

For an effective response, call sequencing has been set up. The first call goes to the village amplifier in a disaster-prone area, so that people in the vicinity can obtain general information about the imminent disaster situation. A second call goes to the village chief, who can personally deliver the information and encourage people to evacuate to a safe place. The final call goes to the related public organizations and officers in the targeted area.

3. The Electronic Bulletin Boards

The third system uses electronic bulletin boards, exclusively to display disaster information and warnings. This disaster notification board system is usually 1.2 meters high and half a meter wide and can display a maximum of 20 words. It can be attached to buildings, or can stand alone with a five-meter-high support.

Currently, 299 systems are installed in disaster-prone areas such as beaches, mountain areas, public parks and lowlands. As soon as disaster information becomes available through the Korea Meteorological Administration using may be nowcasting technology, NEMA and local headquarters select a standard message and activate the system using the Internet.

4. The TV Disaster Warning Broadcasting System

The forth early warning system is the TV disaster warning broadcasting system, which is based on automatic TV turn-on/off functions. Since night time is most vulnerable to disasters, these systems enable TV systems to turn on or even change the channel with automatic volume-up so people receive urgent disaster information even if they are sleeping or watching other channels.

This system broadcasts urgent disaster information as sound or screen messages using the broadcasting station's equipment and a special receiver connected to the home TV set. The Korea Broadcasting System (KBS) is the primary service responsible for broadcasting disaster information.

Currently 4,000 TV sets with special receivers are in operation at central and local disaster management headquarters, at each of the administrative offices, and at related organizations. These are to be expanded for the general public.

5. The Radio Disaster Warning Broadcasting System Using RDS

Similar to the TV disaster warning broadcasting system, the fifth early warning system, that the Korean Government is focusing on, is the radio disaster warning broadcasting system using RDS. This system is based on the technology that can automatically turn a radio on or off, and can activate Agora's amplifying speaker systems.

The system can be applied to any facility that has internal speaker systems, such as a movie theatre or shopping center. KBS is also responsible for broadcasting specific disaster information. The system does not interfere with the existing FM signals, but it requires an RDS (radio data system) encoder to be installed.

The system consists of three main sub-systems, i.e. control, transmission, and warning broadcasting panels. These panels should have an emergency power supply and be resistant to lightning damage. Also, the system is capable of various warning durations and messages.

During Typhoon Maemi in 2003, radio disaster warning broadcasting systems using RDS in five areas were activated, and disseminated the appropriate disaster information.

6. The Automatic Rainfall Warning System

The Automatic Rainfall Warning System can be considered as one of the most directly connected early warning system with nowcasting concept. This system is for localized rainfall warning.

After a one night flash flood killed 95 campers and hikers in the Jiri National Park in 1998, the local observatory system needed to be expanded to monitor local torrential rains which cannot be easily observed at regional level.

The automatic rainfall warning system can measure rainfall in the upper stream, analyze discharge and velocity of river flow in a specific basin and calculate the water level downstream. When the water level exceeds certain criteria, early warnings and evacuation orders can be issued.

When rainfall is actually measured in the observation station in the upper stream, which is powered by batteries and sunlight, the runoff and time of concentration can be determined using a computer program verifying various parameters. Figure 1 and 2 show observation station and warning station of the automatic rainfall warning system, respectively.

The velocity of flow is also determined using the computer program for multidimensional display or by Manning's formula for a simple profile. Since hazard criteria are known by actual tests based on velocity and water level, a dangerous water level can be detected.

The amount of rainfall accumulating in 10 to 20 minutes is used to determine whether warning and evacuation orders need to be issued using the alarm station. The control station and field display post also help to organize the system and inform people about it.

<Figure 1. Observation Station for the Rainfall Warning System>

<Figure 2. Observation Station for the Rainfall Warning System>

This localized rainfall warning system is one of the most effective early warning systems in Korea. It is an actual-input based early warning system using real-time monitoring and nowcasting.

Based on the Disaster and Safety Management Basic Law and Natural Disaster Countermeasures Act, the Korean Government established 148 systems, investing more than 60 million USD between 1996 and 2005. An additional 113 systems will be completed by 2009 at a cost of about 40 million USD.

The role of the central government, the National Emergency Management Agency, is for planning, management of system, and development of techniques. The central budget support is 50% of the total cost and the role of local Governments is to operate warning system, maintain, and educate and publicize the system.

Even though the automatic rainfall warning system apparently looks fancy, it is not perfect, yet. At first, 8 mm/10min of precipitation makes signal, causing frequent false alarms that make the system unreliable. The warning criteria need to be improved according to each region's characteristics through runoff analysis.

In spite of this weakness, the concept and framework of this Automatic Rainfall Warning System can be expanded and applied in various sites for multi-hazards such as typhoon, torrential rain, tsunami, etc. For the expansion of the system, it needs to consider accurate basic input data and information, precise nowcasting techniques, practical warning criteria, and proper locations of each station.

III. Conclusions

These six systems, in operation in Korea, represent good practice in effective community-based early warning using nowcasting concept. An annual review process by NEMA guarantees the appropriateness of these systems' configurations, costs, and positions, while updated information for each system is continually evaluated.

Details of how to quantify warning and evacuation criteria for automatic rainfall warning systems or other early warning systems, however, need to be reviewed and updated based on continuous validation processes including technical assessment. Also, budget allocation and privacy protection are issues to be tackled for the successful implementation of these early warning systems in Korea.

For the future direction for early warning systems using Nowcasting Concept is that it is necessary to construct a "working" Early Warning System using Nowcasting Concept, international cooperation, as well as system refinement, is important to minimize loss of lives in the regional level.

It also needs to expand and integrate currently-available local warning systems into a regional level covering multi-hazards including Tsunami, Typhoon and others, especially for the slope-stability related disasters such as landslide and debris flow. Effective Early Warning Systems using Nowcasting Concept also need to consider emergency action plan and disaster response activities including emergency training.