**Integrated Forecasting System for Abrupt Natural Disaster using Sensor Network and Public Private Community Partnership for Rural Development**


**Abstract**

Rural development policy contains a wide range of areas including locations, constructions, and management of public facilities. The policy process causes a conflict of interests between stakeholders who participate in government, private organization, local resident, etc. To overcome this conflict problem, a public-private-community-partnership (PPCP) model has been used to make a new policy and strategy. In this study, PPCP was used on abrupt natural disasters in agricultural field that have caused numerous human and property damages in Korea. A regional-friendly emergency action plan (EAP) was developed to make counter-measures against the abrupt natural disasters including flood and landslide based on the case studies that have instituted related strategies and policies in terms of PPCP model. An integrating forecasting and warning system using sensor-network technique has been preparing for minimizing the damage from abrupt natural disasters in agricultural field.

**Keywords:** abrupt-disaster, disaster-warning-system, ubiquitous-sensor-network

**1 Introduction**

Abrupt natural disaster can be occurred in a short period due to strong rainfall and cannot be predicted effectively in regional steep grade in mountainous area. One of the representative abrupt disaster is flash flood which is a flood which occurred with relatively higher peak discharge during short duration time defined by World Meteorological Organization. Flash flood can make numerous economic damage without warning. A number of 60.6 % among agricultural and rural facilities in Korea was damaged by localized heavy rain while 25.3 % by typhoon and 14.0% by heavy snow. The economic damage was tallied by about 8 billion US$ due to natural disaster during 2011 and agricultural and rural facilities were occupied by 30.2 % of overall damage including house, farm area, water & sewage system, irrigation facilities, livestock house, greenhouse, etc. Most of damage on rural infrastructure was occurred during localized heavy rain while crop was damaged during typhoon and agricultural production system including livestock house and greenhouse were damaged during heavy snow. Therefore a differentiated disaster preventive plan is very important according to objectives such as rural infrastructure, crop, livestock and greenhouse.

Climate change was recognized as main reason for abrupt natural disaster which has been increasing on its frequency and scale world-wide. Many research groups have interest in forecasting system of abrupt natural disaster to minimize damage of human life. In USA,
IFLOWS (integrated flood observing and warning system) was proposed by National flash flood program development plan in 1978 in terms of flood forecasting and warning system. IFLOW was operated by interconnecting with automated flood warning system to reduce damages of life and property due to flash flow. FRICS (foundation of river and basin integrated communication) has been developed to forecast and manage flood risk using radar rainfall and T/M data in Japan. FRICS is also developing latest technologies using radar and optical fiber to provide river and basin information.

For rapid forecasting and warning of abrupt natural disaster, sensor and network techniques are very important in terms of detection speed, accuracy, and reliability. USGS had installed the real-time monitoring system on steep slope, which can be collapsed, using geophone and extensometer. The information of slope movement can be transferred on USGE. Acoustic emission nondestructive method was also used to predict collapse of rock slope in Japan.

Based on the rapid growth on ICT technology in Korea, sensor and network system can be effectively used on weather forecast, flood monitoring, and warning system using statistical analysis and simulation techniques on scientific prediction and warning system for abrupt natural disaster. And sensor can be improved and the price of sensor was saved by means of integrated sensor and communication module technique and upgraded battery system on size and duration using independent power supply based on solar, wind, and geothermal energies.

The main objective of this research was to improve safety of agricultural and rural facilities against abrupt natural disaster including flash flood, landslide, and avalanches by means of following steps; 1) potential risk analysis of rural facilities by abrupt natural disaster, 2) construction of forecasting platform using short-term forecast, 3) development of warning system using sensor-network technology, 4) application on study areas, and 5) suggest of policy and regulation resulting in developing green-safety integrated model for ANSIM system (Anti-risk System of abrupt natural disasters as an Integrated Model).

### 2 Materials and methods

To construct ANSIM system, four steps were considered including recognition, preparation, warning, and action.

1) Recognition step : evaluating potential risk of abrupt natural disaster with damage category and developing structural & nonstructural long-term disaster prevention method

2) Preparation step : constructing forecasting platform using short-range forecast data to save damages in terms of human life and properties

3) Warning step : developing warning system by means of ubiquitous sensor-network technique to provide real-time information for disaster outbreak

4) Action step : preparing policy & regulation for abrupt natural disaster on agricultural and rural facilities

For accomplishment of research objectives, five tasks were moved including risk potential, forecasting platform, early warning system, policy, and application on study area as shown in Figure 1.
3 Results and Discussion

Risk potential of abrupt natural disaster on agricultural and rural facilities was evaluated to make a improvement and prevention model. The past history for abrupt natural disaster was investigated to categorize the damage type(Figure 2).

- Development of disaster susceptibility evaluation systems for categorized damage types
  - Investigation of disaster susceptibility assessment methods and analysis
  - Application to agricultural and rural facilities
- Development of abrupt disaster susceptibility map
  - Selection a test site
  - Application of assessment method and development of disaster susceptibility map
- Investigation of structural and non-structural disaster prevention methods

And abrupt disaster forecasting platform using short-term precipitation forecast was investigated(Figure 3).

- Establishment of abrupt disaster warning system
  - Investigation of abrupt warning systems in home and abroad
  - Investigation and selection of precipitation forecasting model in home and abroad
- Development of abrupt disaster warning platform
- Platform operation and applicability assessment

In order to measure and monitor the landslide/debris flows in the past the various devices such as of natural slope and water level sensor, optical fiber sensor, CCTV and so forth has been installed upstream regions. And for assessing the slope stability, tiltmeter, crack gauge, inclinometer, borehole extensometer and piezometer have been used. But these equipments are very expensive and need many attachment such as power supply, data logger and so forth. This type of instrument and monitoring systems has no applicability to mountainous terrain of Korea.

Ubiquitous sensor network(USN) technology has been evaluated as the best solution which can be used at the mountainous area communication infrastructure and power is not in place. Low-power wireless sensor network technology can solve the power supply problems at the time of installation of the sensors and relay type wireless communication technology can solve the long distance(over 30km) communication problems. Warning systems has been preparing for abrupt disasters using sensor network technique(Figure 4). In order to measure the debris flows and abrupt floods, since it is necessary to ensure the durability and simplicity contact type water level indicator was developed(Figure 5). The warning system was designed when a abrupt disaster is detected, the warning data will be transferred to national disaster warning system. And the warning system sound siren and transfer warning SMS to local residents. Designed warning system will be applied to more than 10 test region selected through the investigation of disaster history.

Finally, the corresponding policies and regulations to abrupt disasters will be suggested in this research.

- Establishment of a disaster prevention strategy using developed early warning systems
- Development of practical disaster prevention guideline
- Development of structural/non structural guideline for disaster damage reduction
4 Conclusions

Integrated forecasting system for abrupt natural disaster using sensor network system has been developing to minimize human life and save agricultural and rural facilities in terms of ANSIM (Anti-risk System of abrupt natural disasters as an Integrated Model) by propagating potentially dangerous rural area for abrupt natural disaster. Using ubiquitous sensor network system including ITS technology, early forecasting and warning system can be improved in terms of detection time and accuracy to securing rural safe and improving rural life quality. PPCP (Public Private Community Partnership) also be considered to providing ANSIM system on rural area considering the distinct characteristics of the study area.

5 Acknowledgements

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6 References


Korean statistical information service([http://kosis.kr](http://kosis.kr))


![Figure 1: Development of abrupt disaster prevention systems for agricultural facilities](image-url)
Figure 2: Research flow for abrupt natural disaster susceptibility analysis

Figure 3: Research flow for abrupt natural disasters warning platform development
Figure 4: Early warning systems for abrupt natural disaster (example)

Figure 5: Water level measurement sensor and wireless communication module