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Development of a Customer Friendly GIS-based Disaster Management System in South Korea

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Abstract

Purpose: This study explored the improvement and the direction of the smart disaster management system newly attempted in South Korea by analyzing the utilization of the existing system. This study focuses on making it easy to apply to user tasks and improving on site information. **Research design, data and methodology**: Problems were identified through field surveys with administrators in charge of administration and public institutions based on GIS based status board for NDMS which is widely used in Korea. Also, this study attempted to generalize to specialists in disaster management who are more likely to use the system in the future. **Results**: We derived improvement plans and verified the results through expert feedback. The results show that the GIS based status board for NDMS is cumbersome to use due to the vast array of unnecessary information compared to the high expected utilization. **Conclusions**: We found that improving the speed and accuracy of the smart disaster management information delivery system is necessary. Also, it is important to identify reasons for not improve the willingness to use this technology in disaster management and to figure out the process by which field personnel makes decisions that smart disaster information cannot be used for disaster management.

Keywords : Disaster response, NDMS, GIS-based status board, Smart Disaster Management System, South Korea

JEL Classification Code : D70, D74, D83, H75, O21

1. Introduction

South Korea is currently making efforts to apply smart innovation to disaster management. In particular, the Ministry of the Interior and Safety has been implementing a GIS-based integrated situation management system from 2019 to convert disaster management into an electronic map-based. It aims to establish situation management to determine appropriate countermeasures by identifying potential and sudden risk situations from the outset of the disaster.

Until now, disaster safety situation management has focused on simple data collection, reporting, and dissemination of situation information. Therefore, it was difficult to grasp the situation of the site in real-time when recent complex disasters that grow instantly occurred. Hence, it is suggested that the disaster management system should be built to be used in the field-oriented form such as GIS-based integrated situation management system from the beginning of the disaster to solve this problem. AS GIS technology develops, there were a lot of efforts to integrating GIS into a disaster management system because GIS technology provides the users with huge options with informed knowledge. (Jefferson & Johannes, 2016). Gunes and Kovel (2000) introduced the use of GIS for emergency management to build a decision support system. Cutter (2003) emphasized the needs of GIS-based technology which can be applied to the disaster management for practitioner communities. In keeping with these trends,

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Hristidis et al. (2010) argue that computer scientists take a key role in managing and analyzing the data disaster management situation. As a result, applying GIS into a disaster management system has been extensively studied (Cheong et al., 2014; Shrivastava, 2014; Tomaszewski et al., 2015; Rahman et al, 2018).

Since hurricane Katrina, developer and planners seek tools that keep sustainable ways to reduce vulnerability in the event of disasters and remote sensing and GIS provide timely information for disaster management and sustainable planning (Twumasi et al., 2016). Hence, remote sensing has been used with GIS in the disaster management system. (Keskin et al., (2018). Recently Participatory GIS (PGIS) and Volunteered Geographic Information (VGI) have been used and tested to improve and enhance the mapping and sharing knowledge (chingombe et al., 2015; Haworth, 2017). Also, new technologies are integrated into disaster management such as Mobility (Guo & Su, 2012), Automated 3D city modeling (Tiwari & Jain, 2015), and Wireless Sensor Networks (Horita et al., 2015).

Through the extensive literature review, it is found that there are insufficient attempts to identify the actual user-centered problems. While it is found that many prior studies are dealing with only technological issues. However, as Zerger and Smith (2003) shows that user access, implementation, knowledge impediment are should be considered for successful disaster management using GIS. Especially, for a smart disaster management system that can predict and confirm the risk of disaster anytime, anywhere, before or after the occurrence of disasters, is getting important to consider the user's point of view. This study focuses on the user convenience of the disaster management system.

Information is the most necessary to cope with crises where it is impossible to respond rationally. On the other hand, information lacked most in times of crisis such as disasters (Alexander, 2003). The purpose of the smart disaster management system is to efficiently transmit information in the event of a disaster. Smart disaster management system refers to a system that can predict and identify disaster risks anytime, anywhere, before and after a disaster occurs. However, few attempts have been made to identify the problem from a user-centered point of view are insufficient. A large number of prior studies have a focus on the technical aspect of disaster management (Samaddar et al., 2017; Choi & Choi, 2018a; Choi & Choi, 2018b; Choi et al., 2019).

This study identified problems through in-depth interviews with the relevant staffs of government and public institutions on the GIS-based status board for NDMS currently being used as the Koran smart disaster management system. Also, this study investigated the problems that may occur in the group that can utilize the GIS-based status board for NDMS in the future. This study is meaningful in that it attempts to identify the problems and suggest improvements based on the disaster management system which is currently being used in South Korea.

2. Methods

The Korean government has begun to apply ICT tools such as GIS and web data to address safety issues since 2013. It makes possible to obtain disaster information quickly by utilizing these functions. Especially, GIS-based electronic map system improved the quality of disaster risk vulnerability analysis and disaster prevention capability. However, this system deals with only limited disaster information. Despite there is a variety of disaster information available to identify the cause of the disaster, it is difficult to perform integrated disaster analysis and monitoring because of the lack of convenience of presentation.

This study analyzed the GIS-based status board for Korea's National Disaster Management System (NDMS) which supports the NDMS situation management task to improve NDMS to increase its utilization in disaster management. The reason why this study analyzing GIS status is that it is an electronic map-based situation management system built to support rapid decision-making in disaster situations in South Korea. In particular, weather and observation information of 88 facilities based on disaster management such as water level station, bridges, shelters, and dams nationwide. Therefore, it makes easy to understand the disaster situation of South Korea at a glance.

The purpose of this study is to figure out the GIS-based status board for NDMS why NDMS is not useful for disaster management and to improve the practical utilization of the system. Also, it is to derive the work process of GIS status board for efficient disaster management in South Korea. This study conducted surveys and field survey to identify the cause of low utilization of GIS status board. Problems in terms of information and information management for disaster management were identified. The derived solutions were verified through in-depth interviews with government officials.

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Source: Ministry of the Interior and Safety, http://ndms.go.kr

Figure 1: GIS-based status board for NDMS

Table 1: Major issues in system utilization

Organization	Opinion	Department	Responsibility
Local government	"We use our rainfall monitoring system. GIS board is cumbersome to access and difficult to understand in real disaster situations."	Disaster Status Control Center	Operate a disaster warning system
	"The real-time marine information function is not related to our region, so it was evaluated as a low utilization function."	Safety Construction Division	Spread and report on NDMS status
	"Considering the characteristics of our region, the real-time marine information function seems to be low in utilization."	Safety Disaster Division	Responsible for natural disasters
	"The video should be linked to shortening the time for on-site control and spreading and responding to each task in case of a large fire. Currently, it is necessary to share CCTV information by linking with ITS (Intelligent Transportation System), BIS(Bus Information System) and CCTV control center."	Disaster Response Division	Operate a disaster warning system
Central government	"We usually check the necessary information in the internal network (COMIS). There is no reason to access GIS status board. I do not know what functions are available and what this helps."	Forecast Policy Division	Natural disaster forecast and situation management
	"I briefly looked at the screen. It is mostly land information, so we don't need it."	Marine Safety Division	Marine guided ship
Public institution	"There is a separate integrated operating system within the institution and it is sufficient. It is not necessary to use GIS status board and it is unnecessary to use it repeatedly."	Airline Disaster Management Team	In charge of natural social disaster

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3. Data Collection and Analysis

This study conducted online surveys (8 places) and visiting surveys (8 places) for public officials applying GIS status boards.

The Survey was conducted of university students majoring in disaster management to see if the limited opinions of local experts were widely applied. The questionnaire was conducted six months ago at Dong-eui University and Daegu Science University, with 50 students each, focusing on the utilization of the GIS status board. The results show that about 41% of respondents answered positively to the question about whether they are willing to use the GIS status board in the future. On the contrary, about 59% of respondents answered neutral/negative, indicating that there are many neutral/negative opinions.

When comparing the actual utilization evaluation of GIS status board users with the expected utilization of non-users, the two groups responded that ‘situation propagation message’, ‘real-time situation information’ and ‘real-time weather information’ function are highly available. On the other hand, ‘Closed-circuit television information(CCTV)’, ‘field video(disaster)’, ‘Related Agency Emergency Contact Network’ functions are expected to be used above average but the utilization rate is very low.

The opinions about the GIS status board can be divided into two categories. First, it can be cumbersome to apply to user tasks. The survey of university students recognized the functions such as ‘situation propagation message’, ‘real-time situation information’, and’ real-time weather information’ with high utilization. On the other hand, the public official responded that the GIS status board is too diverse and difficult to understand. Especially, the existing features are cumbersome for users to use because the map window which displays the information of the system has a problem. In detail, it is inconvenient to select and manage only the manageable areas, and separate material for summarizing the situation is required.

Second, it is difficult to grasp information on disaster sites. In the survey of university students, the expected usage rate of ‘Closed-circuit television information(CCTV)’, ‘field video(disaster)’ is more than the average, but the actual usage rate is very low. Government officials answered that the means for obtaining real-time field information is limited(CCTV) or difficult to create and share the information. Also, the function of providing disaster site information should be strengthened since there are few people to quickly communicate the situation on-site. In other words, it should be easily adapted to user tasks and improvements should be made in understanding the situation.

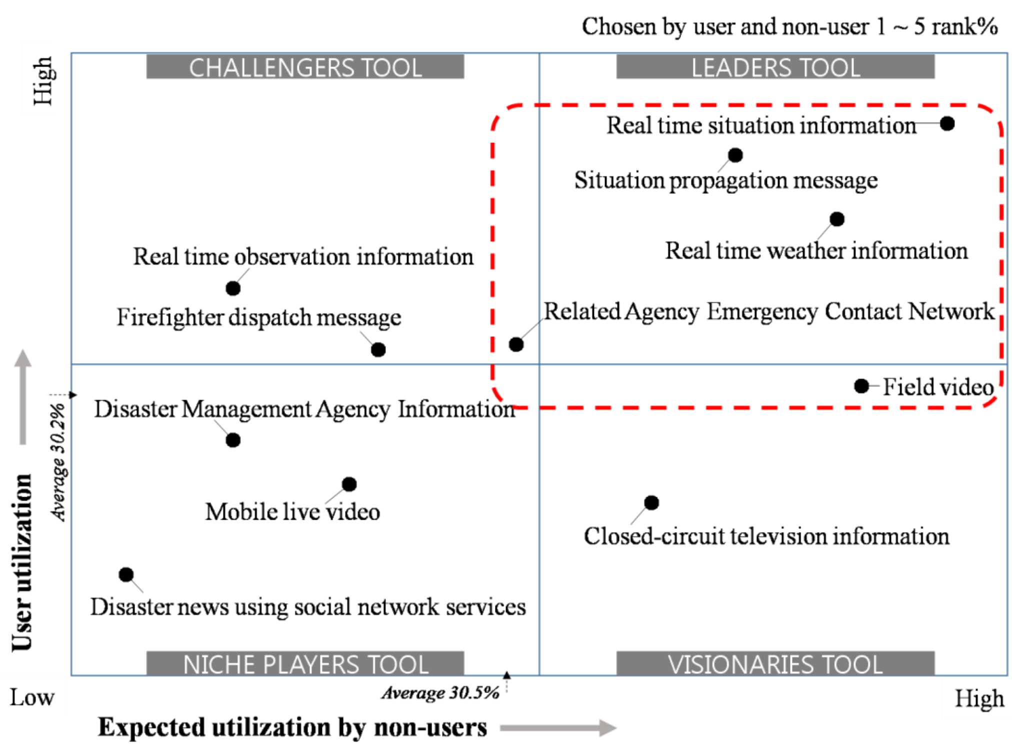

Figure 2: Matrix analysis of GIS-based current status board functions and user utilization

4. Resolution of Problem

4.1. Editing Function in Status Board

As the results of the field survey, we could find two reasons why the existing functions are being ignored by the users. 1) the map window in which the information is displayed in the system changes variably according to the browser resolution 2) the size of the menu located on the left and right of map window is fixed.

The menu portion occupies 30% by default when the system's minimum resolution is 1,280 × 1,024. Although as a browser increases in size, it shrinks, the user's attention is not focused on the information displayed due to the fixedly assigned menu window. Besides, the list of information registered in the system is simply displayed as text and the font size is very small, making it less readable. We found that people who are not familiar with the system have to spend a lot of time to find the information they need due to these reasons above.

If features and services must be provided on a fixed screen as in the fast, this can only be made into complex system UI. This is one of the main reasons for the significant decrease in system utilization. Although existing systems use high functionality, the rate of the actual use of them is low. This is because they are classified into various types of users according to their utilization level and work purpose of disaster management. Without distinguishing these service types, supporting user's demand on only one screen can limit its usability. Based on these findings, a new paradigm service access structure was derived.

The existing situation board has a fixed screen and function layout so that all users had to use it in the same environment regardless of their different tasks. It is also complicated and could not take into consideration the specificity of region and situation because of providing various functions which are not necessary.

The newly designed editing function in the situation board is created according to screen composition by the user, by regional characteristics, by the current situation, and by the organization. Users can use pre-made status board template and create a dedicated status board to use at work.

If users can reconfigure the integrated situation panel with the layout and necessary functions according to the disaster, region, organization, and situation, users can operate a user-friendly status board as a new service paradigm.

4.2. Proposal for Improvement

In-depth interviews were conducted based on the contents being developed to confirm the service concept to be finally improved. Fire Service, police, Central government, Local government, Basic government department based on the keywords 'disaster', 'safety', 'civil defense', 'emergency preparedness', 'foreign protection', 'protection', 'health', and 'industrial accident', it is expected to be used by 5,523 civil servants in South Korea. We conducted in-depth interviews by selecting 70 persons related to 52 disaster management work from 52 institutions, divided into four by service type.

The service types were classified and the detailed functions of the service were derived according to the requirements. 5 detailed functions were suggested 1) screen configuration exclusively for work, 2) various sharing arrangements, 3) situational awareness-situation determination-situation propagation support 4) collection of various information 5) reuse of information shared in the system. In the questionnaire about five service developments, 44% of respondents answered that improvement requirements would be solved, and that they are expected to be useful in the future. 15% of respondents answered that they are not related to work. 41% answered that it is a nice feature but expectation for development is moderate. In the case of non-users of existing systems, the expected utilization survey showed that 74.5% would be helpful for their work.

5. Conclusions

5.1. Summary

This study provides future direction on system improvement by analyzing the user's utilization of the existing system to efficiently build a new smart disaster management system which is recently attempted in South Korea. Problems were identified through field surveys with those in charge of the GIS-based status board for NDMS which is widely used in administration and public institutions in South Korea. We generalized to those majored in disaster management, who are likely to use the system in the future. Also, the improvement was derived and the verification of the results was conducted through expert feedback. In particular, On-line surveys and field surveys were conducted to investigate the causes of low utilization of GIS-based status boards. We proposed a user-centered service using the edit of the situation board to solve the problem.

5.2. Limitation and Implication

This study derived the work process of the GIS status board based on the detailed functions of five service developments verified through in-depth interviews. The service provision process is a process of introducing the final product of the service composition to the developer, persuading the application and improvement. This is the final step in putting the whole process of service design into action. The system completed the process by defining the first response process that is the most needed in the event of a disaster.

Smart disaster management systems without considering the problems of users in the field are difficult to have usefulness. Smart information technology is only a requirement for disaster management. Delivery of information through smart disaster management might be fully implemented. However, if it is not convenient for the user who utilizes it, or unnecessary information is not excluded, it is difficult to have useful information.

It is necessary to improve the speed and accuracy of the smart disaster management information delivery system that the government is willing to implement. If smart disaster managers can’t use developed technology, it would be useless. This study suggests that it is important to figure out the process by which field personnel makes decisions that smart disaster information cannot be used for disaster management and to identify reasons for not improve the willingness to use this technology in disaster management.

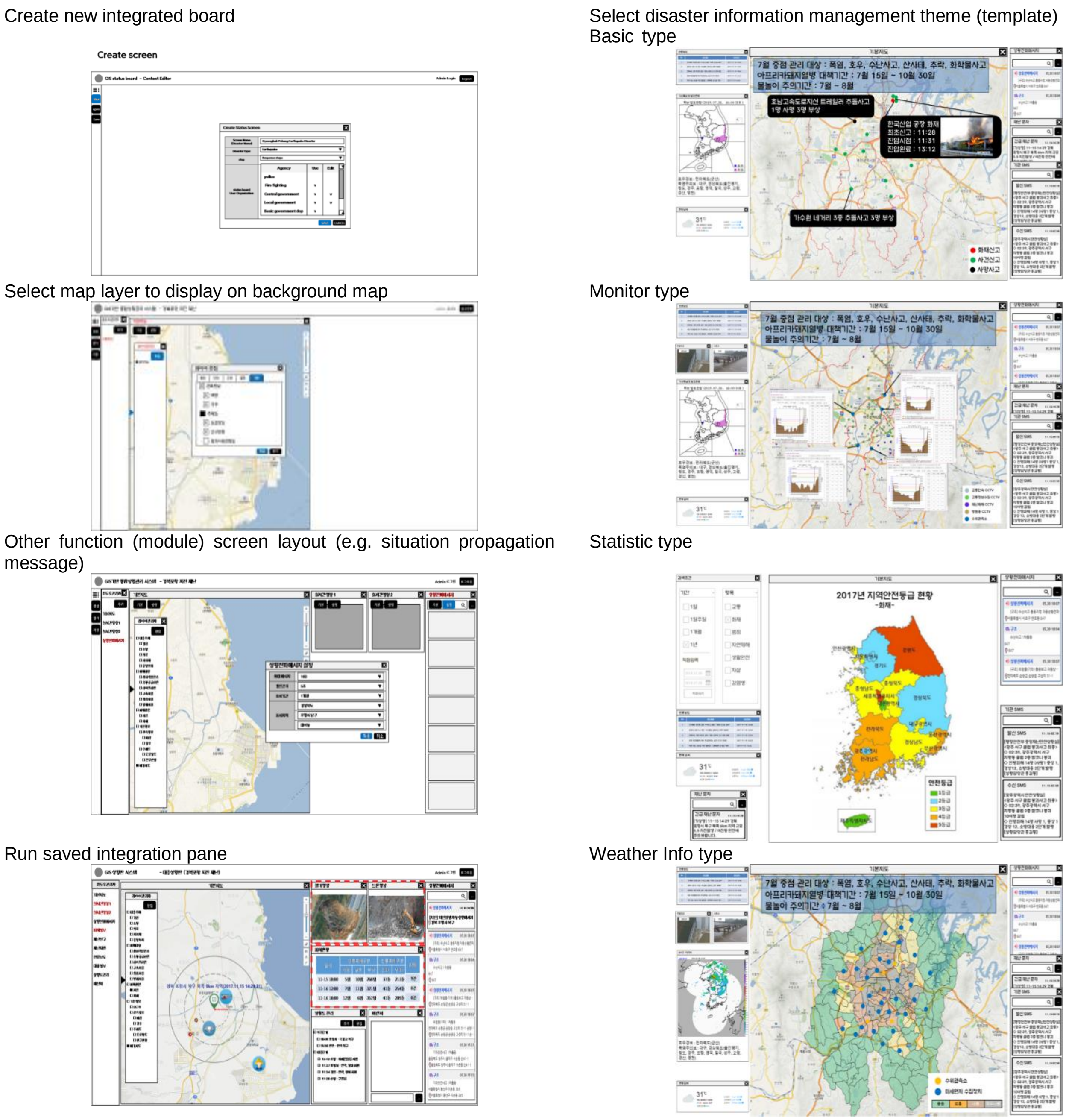

Figure 3: Process of Editing Function in Status Board

Table 2: Service scenarios by level of requirements

Level	Service type	Suggestions	Service development	Detailed function
1	Disaster information management	Depending on the nature of the work required, the screen configuration should be saved, and the screen should be recalled or edited and saved.	Screen configuration for work (User-centered)	• Status board support(work preparation)
2	Disaster information management	Depending on the requirement of a workgroup, data should be shared with multiple users or from shared users.	Arrange a variety of shares	• Share and monitor status panels by type of disclosure target
3	Disaster information management	The reporting process of situational awareness-judgment-propagation should be quick and concise. It can replace the personal mobile instant messenger that most institutions use. The group chat messenger associated with the GIS status board must be supported.	Status panel sharing and monitoring by type of disclosure target	• Internal/external situation propagation • Internal/external situation report • Message business support • SMS support • Press release collection support • 119 center report • Humanities and social network collection support
4	Disaster information collection	Disaster management personnel's work changes by type of disaster information and by the life cycle of disaster management.	Coping with various tasks	• Disaster information presentation • CCTV information display • Drone video display • Inquiry on VR light • SNS video search • Situation and drawing support
5	Disaster information generation	It should be a database so that cumulative statistics or time series management can be used in the future as the continuous use of information input from disaster management work.	Reuse of information shared with the system	• Database construction • Supporting for uploading unstructured data (Excel/Hangul document)

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