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Invited ViewPoint

Information technologies and disaster management – Benefits and issues -

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ABSTRACT

The paper presents brief examples of use of information technology in different disaster management stages such as disaster response, recovery, preparedness and risk reduction. We find discussions on the use of information technology in each stage are scattered. A holistic perspective on the use of information technology throughout all disaster management phases is missing. Information systems play essential roles in recording, exchanging, and processing information. The combination of different roles enhances system performance. In so doing, we argue for the importance of having a comprehensive strategy of technology use throughout different disaster management stages, and the necessity of data standards for information sharing among different systems and stakeholders.

Contents

1. Introduction – technology progress and disaster management

Information is crucial for effective disaster management. Social media could be used as new information sources for disaster relief agencies. It enhances situational awareness as well as two-way communication [1**]. Tim, Pan [1] report that during Hurricane Sandy in 2012, around 800,000 photos were posted with the hashtag, #Sandy on Instagram. These photos also showed their geographical locations. In the Nepal earthquakes in 2015, Digital Humanitarian, [2] which formed a digital volunteer community, developed various digital tools for disaster management [3]. More than 3000 volunteers contributed to create a map and 1500 reports were released showing affected areas and the number of victims on the map. The information was used extensively by the American Red Cross and the Nepali government in delivering relief operations.

While these new information technologies represented by social media have changed the way that relief organizations collect situational information [4], there are scarce discussions about how those organizations should implement these technologies with certain strategies. When discussing the implementation of information technologies with Japanese local government, we have found there is no holistic strategy that indicates “who” should use “which” technology for “what” reason. A general disaster management plan defines a chain of command in the time of a disaster [5]. The national government recommends developing an ICT (Information and Communications Technology)-Business Continuity Plan (ICT-BCP) which guides government officials how to continue ICT facilities after a disaster [6]. This plan is not enough for officials to understand how to use information technologies and for what reasons, when responding to an unexpected disaster event.

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In this paper we discuss the benefits and issues Japanese local government face in using information technologies for effective disaster management.

2. Application of technologies to the field

We follow the traditional four stages of disaster management, risk reduction, preparedness, response and recovery [7], and illustrate how information technologies can be used in each stage.

When describing the way information technologies are implemented, we regard the essential roles of information systems as follows; information record, information exchange, and information process [8]. After a brief description of technology implementation cases in each stage, we summarize which role the information system offers.

2.1. Risk reduction

Monitoring technology for buildings [9], unmanned aerial vehicles (UAV) [10**] and sensor network systems [11] help local authorities reduce disaster risk. A sensor network system has been deployed in a major bridge and road infrastructure. It reports on vulnerability of infrastructure by monitoring degradation and endurance. Moreover, the sensor can detect water-level rise in a river. These systems enable a local authority to improve prediction of river flooding and real-time situational analysis. While sensor data requires frequent observation, using open satellite image is increasingly popular in monitoring land use and change [12]. Recorded information would be useful when integrating hazard assessments into disaster planning [13].

Information systems support information *record* in disaster risk reduction. Recent development of AI technologies would enable disaster managers to analyze those recorded data and create an alert. An AI platform which can detect water rise from social media posts has already been developed [14].

2.2. Preparedness

Information collected by sensor network systems can strengthen community-based disaster preparedness [15] as people learn about vulnerable areas. Information technologies provide an opportunity for scenario simulation by living-lab style [16], and support field exercises [17] prior to a real disaster. One example is a Virtual Reality (VR) training system. This system teaches people how to survive a disaster [18*]. Users can learn what a disaster situation looks like visually and how to evacuate from the office building or schools in an indoor situation. The system could show how difficult avoiding smoke during evacuation is, and how people panic under a disaster situation. The VR technology has been adopted by hospitals [19]. It supports emergency medical training.

Messenger applications as well as an online dashboards help citizens report their situation and requests. Specific algorithms can detect predefined critical information and categorize it into specific areas and topics [20]. These technologies can be used in a field disaster exercise. Information systems also can create a knowledge repository based on the past disaster experiences [21].

Information systems support information *exchange* in disaster preparedness.

2.3. Response

In the same way, information systems play an essential role for information *exchange* in the initial response. Once a disaster occurs, local governments need to conduct the following operations [22*] in Japan:

(1) confirming the whereabouts and safety of residents,
(2) establishing and operating evacuation centers,
(3) transporting and managing relief goods,
(4) supporting evacuees and creating evacuee lists, and.
(5) issuing disaster victim certificates.

These operations are quite different from daily-basis tasks. It requires situational information that can be enhanced through social media to deliver these operations [23]. Information systems enhances situational awareness [24–26] and decision making [27]. As discussed previously, social media has changed the way citizens react to a disaster. Victims can report situations around them through social media. Among all 1741 local governments in Japan, 941 out of them (54%) were using social networking services (SNS) for disaster response in 2017.[1] 919 out of 941 organizations only use SNS for information sharing, while 22 local governments collect situational information from SNS. It is not easy for them to have enough human resources to extract relevant information out of SNS [28]. Indeed, during the Great East Japan Earthquake in 2011, an ambulance was called in vain, due to a false tweet that a person was injured. There was also false information that a lion had escaped from a zoo in Kumamoto during the 2016 Kumamoto Earthquake.[2] Such false information would lead to public sectors responding unnecessarily. Critical thinking was suggested to protect one from such false SNS messages [29]. DISAster-information ANAlyzer (DISA ANA) was implemented to make the SNS information more trustworthy [30]. From another perspective, huge numbers of volunteers got together and developed a map that showed situational reports from residents which was called "shinsai.info".[3] Human resources are not enough within a local government. After the 2011 Earthquake, "shinsai.info" has been elaborated into a "code for Japan". They started dispatching IT professionals to local governments. This may solve an issue on recruiting IT resources in local governments at the time of emergency.

2.4. Recovery

After an initial response, a local government is in charge of supporting residents to get back to their normal life. A series of natural disasters in 2018 show the importance of evacuation centers operation and management.[4] Recognizing necessary resources for evacuees, and managing relief goods, are essential. Information systems can be used for coordinating available resources [31]. However, no information systems were employed for connecting supply side and local authorities. As an example of managing evacuation center operations, Sahana [32] is an information sharing system for humanitarian assistance during disasters and was developed originally by programmers in Sri Lanka just after the 2004 Indian Ocean earthquake and tsunami. The system is based on a free and open software and has been used extensively during disasters such as the 2010 Earthquake in Haiti [33]. Sahana was introduced to the Japanese open source community in 2010. After March 11th, 2011, the Sahana Japan Team (SJT) was set up and those industrial volunteers developed the system for Iwate with the help from SJT [34]. The system was ready eventually, at the end of May, but it was late, as most of the evacuation centers were about to be closed by July and the residents were to move to temporary housing. It would have been more useful if the system had been provided much earlier in March or April. Even so, the system was used experimentally in some cities [35].

Another essential operation is the issuing of disaster victim certificates. An information system for processing disaster victim certificates was available during the west Japan flooding of 2018. However, as it did not connect to other systems for disaster recovery (i.e., evacuation center management), so victim data was not shared.

In the line of situational awareness, a "Reconstruction Watcher" that streamed videos and pictures of areas affected by the Great East Japan Earthquake 2011 [36] was developed [37]. Social media empowers local

[1] Last access on December 11th, 2018 at https://www.kantei.go.jp/jp/singi/it2/senmon_bunka/pdf/h2911SNSkatuyou_chousa.pdf

[2] Japan Times, 21 July 2016. "Man arrested for posting false tweet claiming lion on the loose after Kumamoto quake," https://japantoday.com/category/crime/man-arrested-for-posting-false-tweet-claiming-lion-on-the-loose-after-kumamoto-quake

[3] Last access on January 16th, 2019 at https://tech.nikkeibp.co.jp/it/article/COLUMN/20110811/365024/

[4] More than 400 people evacuated even 3 months after west Japan flooding. Nikkei, October 5th, 2018 at https://www.nikkei.com/article/DGXMZO36182580V01C18A0AC8Z00/

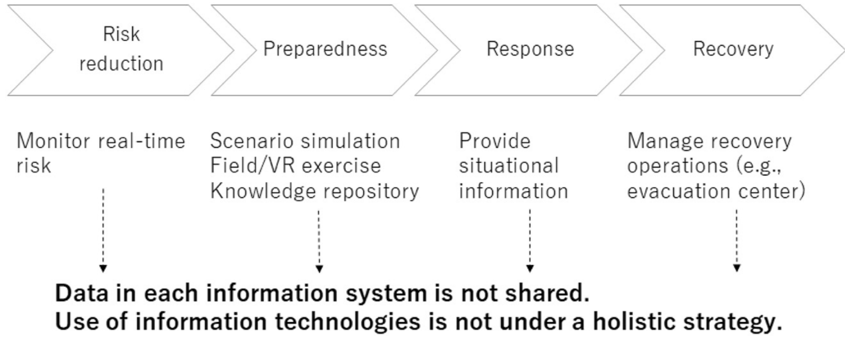

Fig. 1. Role of information systems in different disaster management stage.

communities by enabling interactive communication [38] and enhances collaboration with disaster relief agencies [39].

Information systems are supposed to *process* information for disaster recovery but integration of data in different systems is an issue to be resolved.

3. Discussion

Information systems help people record, exchange, and process disaster-related information throughout four disaster management stages (Fig. 1). As we illustrated in the previous section, discussions of information technology use are fragmented and no holistic view or strategy exist throughout different stages.

In risk reduction, sensors, open satellite images and UAVs help local governments record real-time situation of land, rivers and critical infrastructure. Information from these tools would show vulnerability and risk. In the preparedness phase, the main activity for local authorities is a disaster field exercise. Online dashboards and SNS are used as communication means for exchanging information during the exercise. A VR training system provides people with simulated experience [18]. Once a disaster occurs, gaining situational information becomes essential. Citizen-generated information through social media and open digital tools such as Open Street Map could increase situation awareness yet managing these tools and information remain as issues to be addressed.

Data that is generated in the previous stages is essential to recovery operations. However, the design of information systems may well be carried out independently in every stage. The combination of different systems would work well, in sorting out issues in the field [40*]. For instance, when operating an evacuation center, the following operations are required:

a) to keep track of the statistics such as the number of victims as well as vulnerable people to a disaster, which includes the injured, the disabled, elderly, pregnant women, children and the others who need assistance, and provide them with necessary care including medicines and medical support
b) to keep track of necessary foods and goods and provide the victims with them

During the Great East Japan Earthquake in 2011, the above operations were needed, not only for victims at evacuation centers, but also for the people who stayed in their own houses around the evacuation centers.[5] Accordingly, it was necessary to get the information on where those victims who needed the support were staying.

Now that we have tools such SNS, one could keep track of the victims staying at their own houses around the evacuation centers by mining the SNS messages with the Global Positioning System (GPS). During the Nepal earthquake of 2015, information about needs and availability of resources was posted [41]. Online neighborhood-based forums were formed in the 2007 California mountain fire [42].

[5] Last access on January 29th, 2019 at http://www.fukushihoken.metro.tokyo.jp/joho/soshiki/syoushi/syoushi/oshirase/hinanjyo_kanri_unei.files/hinanzyouneishishin.pdf

In the same vein, risk information in the preparedness phase could be connected to real-time information collected in the response stage. We assume this enhances situational awareness and community resilience [43]. Local governments can create a specific real-time alert that is useful for people living in a highly vulnerable area, by combining risk and real-time information in the initial response. In another context, we assume that UAVs can provide a holistic view for situational awareness throughout different disaster stages. In doing so, we need a holistic strategy of information technology use and standards for data sharing among different systems or different stakeholders [44]. This has not been considered in Japanese local governments.

4. Conclusion

In this paper, we briefly review the use of information technology under a disaster. From local government's perspective, essential roles of information systems, i.e., information record, exchange and process, are critical in effective disaster management. Information record and exchange are initial functions of information systems prior to a disaster, while information process and exchange become core to disaster relief operations. Currently we do not see integrated discussion of technology use in each disaster phase. Those discussions are divided into "before" and "after" a disaster.

We argue 1) the necessity of a strategy for effective use of information technology throughout the four disaster management stages, and 2) the necessity of data standards among different information systems and stakeholders.

The more IT-enabled disaster responses and risk reduction progress, the more IT resources within local government are required. They face difficulties in managing digital tools and information. Collaboration with external institutions and IT professionals is essential. In addition, developing a holistic IT strategy including how to manage IT resources is necessary. It requires a long-term perspective whereas disaster management at each stage deals with a wicked, short-term problem [45,46]. Noticing such a dilemma in practice, we believe the study of disaster management and information technologies enhances effective disaster management for local governments, which are in the front line of disaster preparedness and response.

Conflict of interest

None.

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[**] Of outstanding interest.

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