Development of cross-sector coordination system based on the process technology

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Abstract

The recent series of intense natural disasters in Japan are characterized by their unpredictability, the random and widespread damage they inflict on infrastructure and human life. As such, these realities offer opportunities for evaluating nation-wide response strategies. A hard-won crisis response and recovery formula states that often the most severely impacted areas remain without assistance because the other, less afflicted areas have a greater ability to call for help. Japanese disaster management plans, which detail the processes that must be followed in the aftermath of a major emergency, are conceived on separate prefectural/regional and municipal/local levels. Accordingly, national governmental directives assign the municipal governments with the task of setting up and operating response and recovery centers for evacuated populations to receive immediate relief and be integrated into longer term recovery agendas.

Local disaster management plans come as a document: a thick manual whose instructions remain abstract and poorly understood by local would be disaster managers and their untrained personnel. Field reporting and the gathering and assessment of crucial information from the field is likewise a quasi-analogue process, and in Japan is quiet often carried out at shelters with pen and notebook.

Recognizing that multiple data flows are a key factor in successfully managing disaster response and recovery processes, Japan is turning towards resilient ICT based applications to address these constraints. In Japan series of intense natural disasters are a tangible pressing matter and much attention is being given to the Japan Revival Strategy, that is achieving operational efficiency in the local governments. Successful initial response and recovery depend on vertical integration and cross-sector coordination, collaboration, and communication facilitated by technology and ongoing interagency relationships. Quick recovery from a major emergency, therefore, is a synergetic process, effectively utilizing available cross-sector collaborations to build on pre-determined strategic planning processes.

The research develops to define the standard processes for a comprehensive disaster response management system that applies ICT based collection and simulation technologies to furnish crisis managers with optimal solutions for various post disaster scenarios by the process-technology. Taking advantage of emerging synergy between the local and central governments, the study intends to further develop an existing developed system that provides disaster managers and victims access to reliable multilateral information. “BOSS”, standing for “Business Operation Support System”, is a cloud system application for total disaster response management that is designed to perform as a navigation system for large-scale emergencies.

Novelty of the research is a unique and an innovative framework based on the past real disaster responses data analysis that is defining about 500 comprehensive processes for 47 kinds of response field. And the necessary all related documents, manual, format, guideline, linked system etc. are databased and to be used in BOSS system.

While the research focuses on developing the earthquake and floods case, in the next research step, BOSS can be applied to all hazard approach that face similar processes.

Keywords: Decision making; Process approach; management system; BOSS

1. Introduction

Disaster management plans (DMP) which detail the processes that must be followed in the aftermath of a major emergency are conceived on separate national, prefectural/regional and municipal/local levels. Accordingly, a direction of prefecture assigns the municipal governments with the task of setting up and operating response and recovery centers for evacuated populations to receive immediate relief and to be integrated into longer-term recovery agendas. Yet, hard-won crisis response and recovery formula state that often the most severely impacted areas remain without assistance because the other, less afflicted, areas have a greater ability to call for help. Similarly, the farther afield an area is from the center of the country, the longer it will take to fully recover. In the event of a natural disaster such as an earthquake, the regional and municipal governments are directed to set up and operate by themselves. In their efforts to contend with an overwhelming list of emergency duties, municipal directors and employees adhere to predefined generalized disaster response protocols. The management plans that they are expected to follow are devised according to nationwide indicators, with slight variations to account for unique local physical and demographic circumstances.

These analog documents come as a thick manual whose instructions remain abstract and poorly understood by local would be disaster managers and their untrained personnel. Besides, field reporting and the gathering and assessment of crucial information from an affected area is likewise transmitted and recorded in a non-coordinated fashion, generally via haphazard cellular communication and later, in shelters, with pen and notebook. Moreover, while DMP often recommends regional collaboration and mutual assistance between adjoining municipalities, they rarely provide more than generalized prescriptions for how this might be achieved. Thus, in the event of a total disaster, this mutual action tends to not succeed due, among other things, to differences in priorities, resources, methods and organizational recourse for incoming staff and structural support. This problem is compounded when damage is inflicted in the boundary areas of municipal governments, where an absence of support leads confused and disorganized residents to flee to other cities or villages, a scenario that leads to further disarray and muddles efficient handling of the crisis.

Our research group analyzed DMPs for wide-area support or effective emergency response [1]-[4]. The description was analyzed in local disaster management plans drafted by supporting local governments and supported ones if standardization of such descriptions could bring smoother and more effective implementation of plans [1]. An effective initial response immediately after a disaster occurs is not easy to provide human and material resources. The analysis that the initial responses are taken by the government of the town of Yabuki, Fukushima Prefecture in the case of the 2011 Tohoku Earthquake for the initial five days are achieved [2].

Responding to this predicament, Japan turns to resilient ICT based applications for their solution. In Japan, earthquakes are an ongoing concern and much attention is being given to the Japan Revival Strategy that states the disaster-resistant ICT infrastructure and local cloud services should be introduced to promote safety and computerization, as well as achieving operational efficiency in the local government. We developed the BOSS (Business Operation Support System) to facilitate the vertical integration and cross-sector coordination by technology and ongoing interagency relationships.

Quick recovery from a major emergency is a synergetic process, effectively utilizing available cross-sector collaborations to build on pre-determined strategic planning processes by the BOSS. Recognizing that resilient integrated data flows are a key factor in successfully managing disaster response and recovery processes, this system proposes to define the standard processes for a total disaster response management system. It seeks to furnish crisis managers and affected residents with a navigation tool, supported by ICT collection and simulation technologies, that offer optimal solutions for various post-disaster scenarios. Taking advantage of the emerging synergy between the stakeholders, the study intends to further develop an existing prototype that provides disaster managers and victims access to reliable multilateral information.

2. Principle of BOSS

The triangle between the disaster basic principle, system developments, and training/ education is important for real disaster responses. Based on the disaster basic principle, the individual system and technical data platform perform those functions (Fig. 1). For the training and education, SOP (Standard Operation Procedure) and the developed systems can be checked/ updated by the training. Under the designed SOP, systems and training, concerning stakeholders can perform for real disasters. BOSS stand at the support and operate the disaster standard operation procedure.

BOSS uses a three-step analysis. “Input”, such as natural hazards or industrial accidents, are evaluated the damage they inflict to a given “System”, which is composed of predetermined engineering, social and economic organizational components. The output comes as an appropriate “Response” which is intended for government or company leadership and/or individual recipients (Fig. 2). The application analyzes and evaluates past and present damage conditions with preset management procedures to provide:

(1) designed responses to national, regional and local leadership and

(2) vital and trustworthy information to displaced survivors.

Applying four integrated variables (Fig. 3), Hazard/Damage/Response/Impact, BOSS can map out multilayered simulated alternatives and offer effective disaster responses that are based on an analytical triad of (1) past disaster experience, (2) the current conditions in the field and (3) prefigured disaster management protocols. Using a unified managing index, BOSS conducts onsite damage evaluations by applying the assembled information to about 500 pre-set disaster processes in 47 categories to define content specific responses. For the effective disaster responses, this research framework four components which are impact analysis from hazard analysis and response simulation, functional location management, information management, and governance/ team building to operate all components (Fig. 4). The system can act as a single-source information hub to provide municipalities with coordinated responses. At the same time, it also enables a vertical format for information exchange between municipal, prefectural and central government disaster managers. The knowledge accumulated from these exchanges is fed back into the system to create a continuously updated version (Fig. 5).

Business Operation Support System (BOSS) is a WEB system application for total disaster response management that is designed to perform as a navigation tool for large-scale emergencies. BOSS, while filling the gap between pre-established demographic data and resource availability and the workable understanding of on-site post-disaster realities, also provides particularized procedural recommendations for human and physical resource allocation, including estimate time-driven workload allocations for diverse categorized scales of response.

BOSS is meant to increase the capacity of disaster response by providing a single, cohesive platform for disaster management that can support collaboration between small and medium-sized local governments.

BOSS is written in PHP, a web scripting language that applies the SQL relational database management system to calculate, categorize and distribute individualized interactive information units that seamlessly integrate and interface with current hardware such as smartphones and tablets/iPads. The software offers users access to dynamic information and visualizations by connecting with preexisting platforms such as Google Maps and GIS data links.

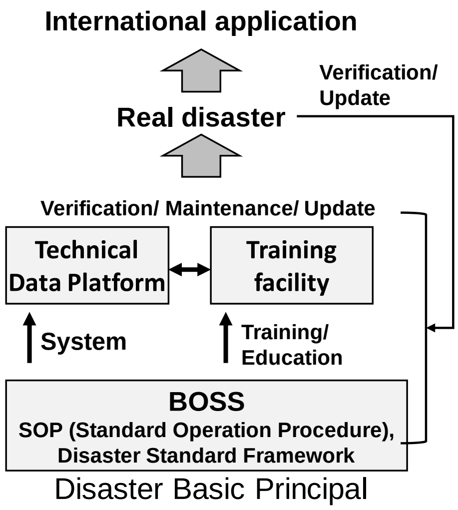


Fig. 1 Triangle between the disaster basic principal, system developments and training/ education

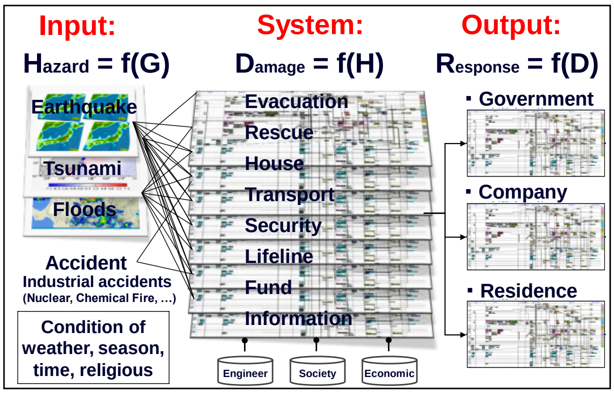


Fig. 2 Three-steps analysis

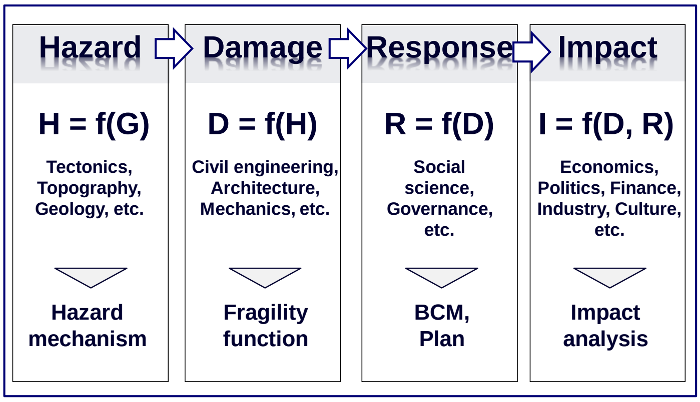


Fig. 3 Four integrated variables

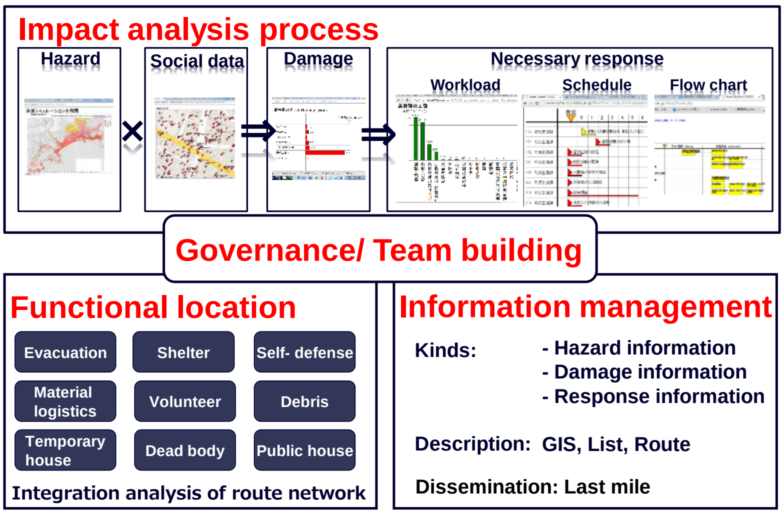


Fig. 4 Components of effective responses

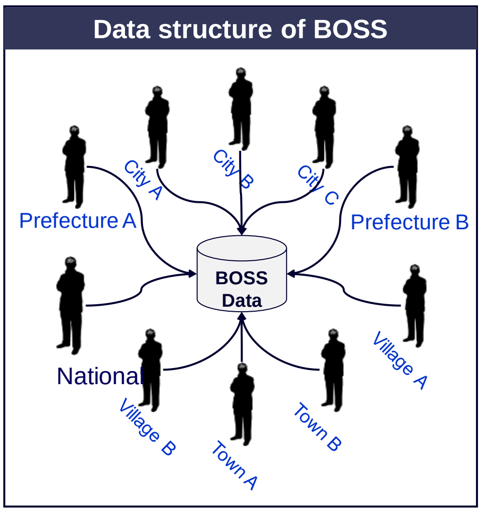


Fig. 5 Structure of data system of BOSS

3. Analysis of BOSS

The interface layer of BOSS consists of four interface layers (Fig.6). The big process layer shows the response categories of 47 kinds of responses, each big process response has a middle process layer to describe the middle process flow charts. Each middle process has own detail sheet to explain the contents of the middle process. And, the details sheet explains the contents of the middle process. To manage, compile and integrate the necessary data, related system, information and documents (Fig. 7). The documents linked to the detail sheet have a checklist, local disaster management plan, past real disaster records, etc. The local disaster management plan can be linked from the details sheet with the address of each page of the plans (Fig. 8). The developed system is innovative as it serves a unique opportunity to develop, test and improve resilient ICT disaster management applications within a multi-cultural, national research framework. The BOSS will be combined with current other disaster response and recovery technologies. The technologies can link individual network events with geographic information to generate multi-user communication services. These applications facilitate the gathering of demographic data from a given population. They also can compare, simulate and predict crowd behavior, providing site and wide-area analytics by segmenting individuals, streets, neighborhoods, communities, municipalities, regions according to multiple pre-configured attributes. The applications are autonomous and facilitated by nanosatellite infrastructure that operates even after a major quake when electricity and cellular communications may be rendered inoperative.

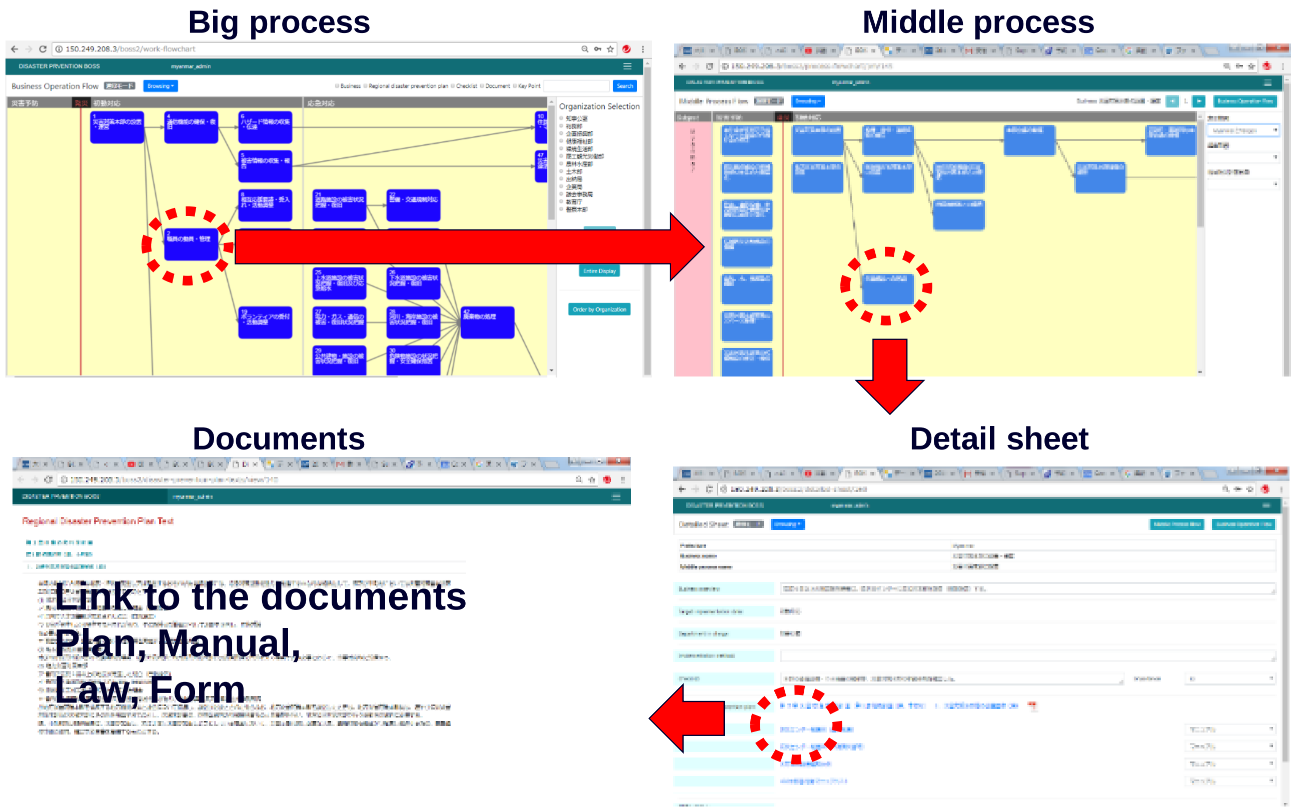


Fig. 6 Interface layer of BOSS

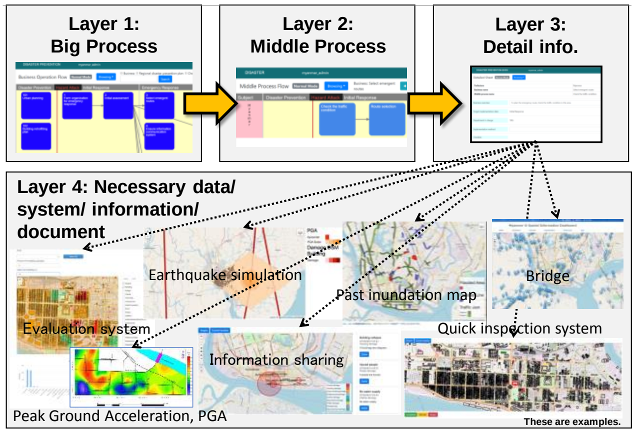


Fig.7 Necessary link to the data

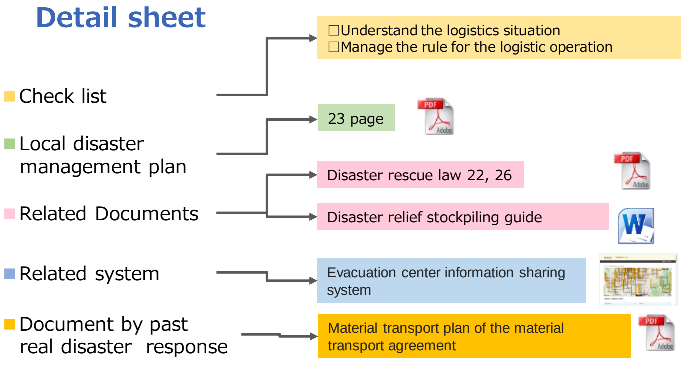


Fig. 8 Knowledge in the detail sheet

The intended outcome from the BOSS will be an enhanced ICT based total disaster management system that can function in the complex, fluid, and unpredictable post-disaster environments. The system aims to create synchronized, user-friendly, system tools that can generate real-time disaster information, interactive maps, and simultaneous data analysis to support the navigation of the disaster management process.

The system will (1) increase systematic communication between national and local disaster managers; (2) furnish up-to-the-minute response processes to assist multi-level leadership in making informed decisions; (3) offer decision-makers an interactive platform based on easy-to-follow info-media (4) automatically reconfigure its output to accord with emerging circumstances and pre-arranged procedures.

The research intends for the merger of these technologies to result in a product that will provide tactical analyses on the prefecture and municipal management scales which are based on the monitoring and evaluation of changes in pre- and post-disaster infrastructure and behavior. Because it is mobile and self-updating, the system applies to diverse population sectors and geophysical circumstances while also taking into consideration various cultural variables and ethical concerns for collecting and disseminating data generally considered sensitive. Aware of the private nature of this material, the data usage will be subject to a culturally sensitive privacy enforcement policy built-in to the software and designed to ensure the safe processing and storage of the accumulated personal information.

The multidisciplinary research approach is well suited to undertake this study. This research – composed of civil engineers, software designers and information management experts, cultural anthropologists and specialists in civil defense and structural mitigation, disaster response and recovery –apply the complementary expertise to jointly formulate, design and construct collection-and-simulation software that can produce optimal, integrated site-specific solutions for post-disaster scenarios.

The technological collaboration will be undergirded by ethnographical inquiry that will help in defining the standard disaster response processes for the needs and abilities of their respective national user base. The researchers conceptualize devising an advanced tool of an application that can handle the efficient input/output of the huge amount of critical data necessary to manage complex multilateral response and recovery processes. Operating as a kind of automated Command and Control center, the BOSS cross-refer past events with incoming information and disaster management protocols to offer relevant and informed guidelines for users in the field.

The methodology combines practical and theoretical examination with parallel ethnographic field inquiries and collaborative software design development including architecture, graphics, and operation. In the study, we collected and analyzed the text files of the varied DMP concerning municipalities. As a result, these plans with real disaster response data were categorized and evaluated according to 47 pre-determined categories and 500 processes [5]. Table 1 shows the categorized 47 kinds of the disaster management framework.

The BOSS is initially database 47 kinds category as for big process. Each big process has middle responses for different phases. Fig. 9 shows the number of responses (middle responses) for different phases in Kumamoto prefecture by hazards (Earthquake and floods case). The difference between earthquake and floods mode shows in a warning phase. Generally, the responses for floods have some time for the preparedness in the warning phase. Therefore, the BOSS wears the responses for floods in warning phases.

Table 1 Categorized 47 kinds of disaster management framework

ID	Category	ID	Category as for big process
1	Organization management	1	Management of disaster management headquarter, EOC
		2	Planning of disaster management plan
		3	Planning of recovery and reconstruction plan
2	Information	4	Assurance of communication equipment
		5	Collection and communication of damage information
		6	Collection and communication of hazard information
		7	Warning of evacuation and safety information
		8	Response to public and mass media
		9	Correspondence through consultation desk and telephone
		10	Land use management
3	Human resource management	11	Management of human resources
		12	Correspondence with important people
		13	Development of a mutual support system
		14	Disaster management support of aviation and self-defense forces
		15	Management of voluntary disaster prevention organization
		16	Management of community disaster prevention organization
4	Rescue / emergency activities	17	Emergency search and rescue
		18	Support for medical, sanitation and psychological issues
		19	Handling of dead bodies
5	Finance / Finance	20	Implement economical/ price stabilization measures
		21	Assurance of finance and liabilities
		22	Security of financial transactions
		23	Responses related to law and regulations
6	Life support for victims	24	Management of emergency shelter/ places
		25	Procurement and supply of goods/ materials
		26	Response to necessary care for vulnerable people
		27	Restoration of educational facilities (schools and cultural heritage)
		28	Collection of donations
		29	Assurance of finance and life support
		30	Recovery of company management
7	Housing reconstruction	31	Quick inspection of buildings
		32	Repair or demolition of residential facilities
		33	Inspection of residential houses
		34	Issuance of damage certification of residential houses
		35	Construction of emergency temporary housing
8	Social infrastructure system reconstruction	36	Recovery of roads
		37	Assurance of security and traffic
		38	Recovery of railways
		39	Recovery of agricultural land and facilities

		40	Restoration of water supply
		41	Restoration of sewer systems
		42	Understanding the damage and restoration status of facilities related to electricity, gas, communications, and oil storage facility
		43	Understanding the damage and restoration of river and coastal areas
		44	Understanding the damage and restoration of public buildings and facilities
		45	Elimination of hazardous materials
		46	Removal of obstacles
		47	Operation of waste

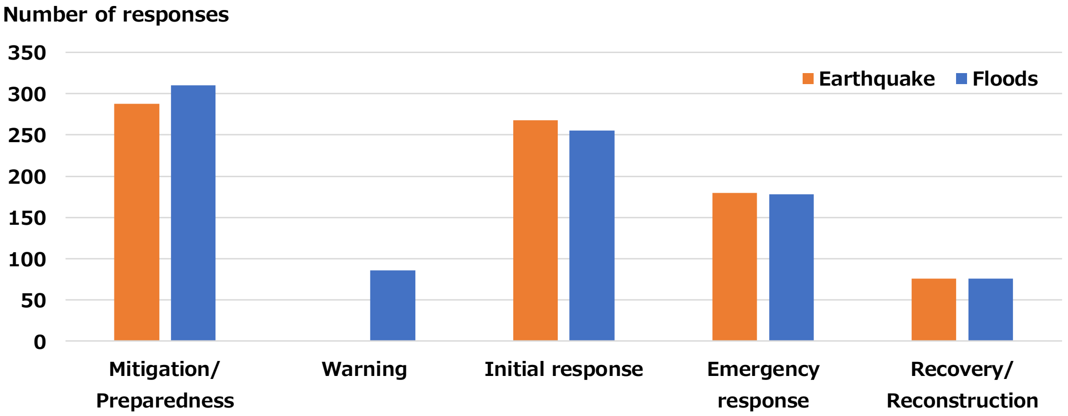
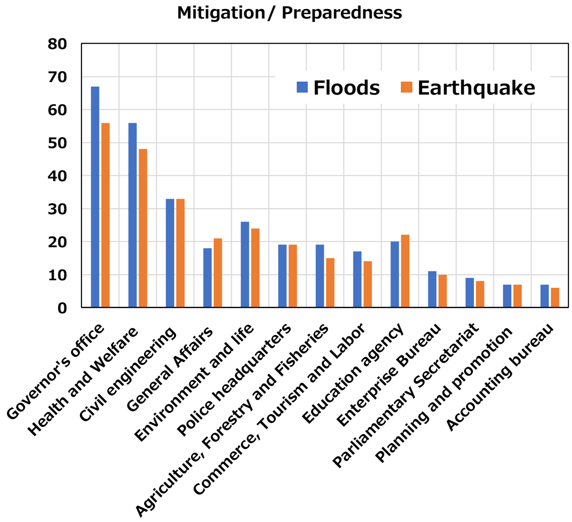
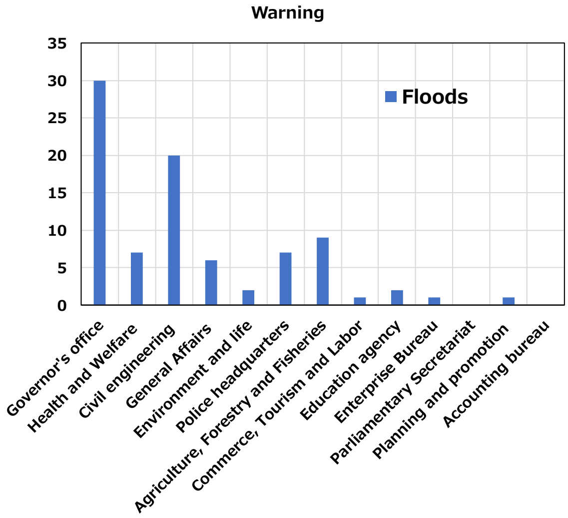


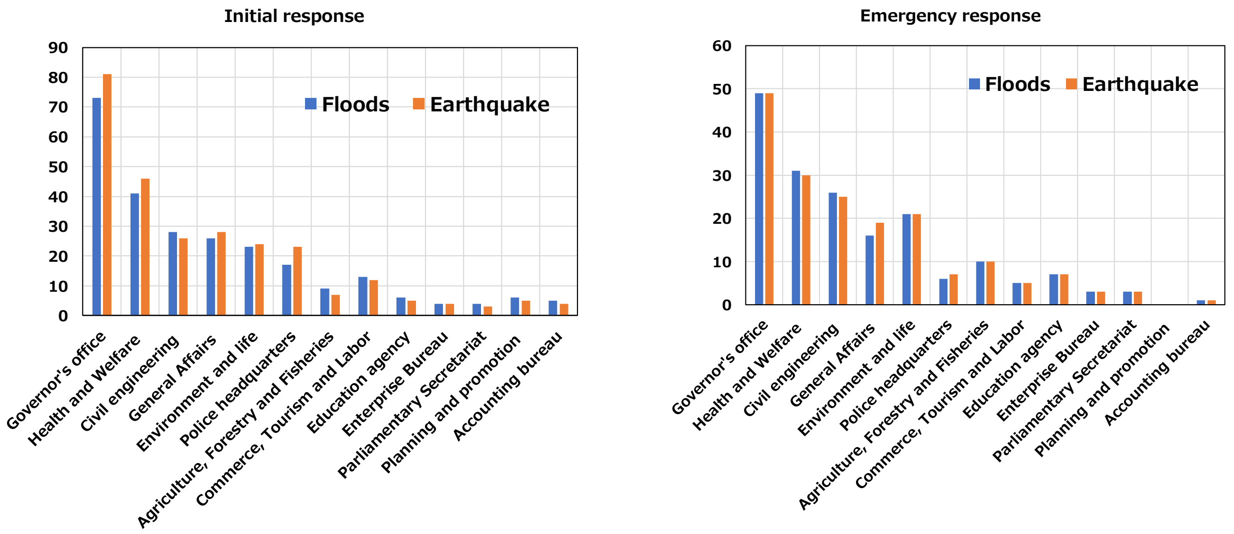
Fig. 9 Number of responses (Middle responses) for different phases in Kumamoto prefecture



(a) Mitigation/ Preparedness phase



(b) Warning phase



(c) Initial response phase (d) Emergency response phase

Fig. 10 Number of responses in each phase for the organizations

Vertical and horizontal coordination among different stakeholders are key parameters for the effective responses. Fig. 10 calculate the number of middle responses in each phase for the different stakeholders in Kumamoto prefecture. The governor's office needs to manage many of responses. In the warning phase, the earthquake responses such as related to the earthquake early warning are not described due to the limitation of short early warning lead-time. Fig. 11 shows the number of middle responses for the categories as for big process in Kumamoto prefecture and Kumamoto city. The important command for prefectures is a coordination of mutual support among concerning stakeholders. Development of a mutual support system covers fifteen percent in the whole middle responses in Kumamoto prefecture (Fig. 12 (a)). One of the high works loaded response is an emergency shelter management for municipalities. Management of emergency shelter/ places need thirteen percent (Fig. 12 (b)).

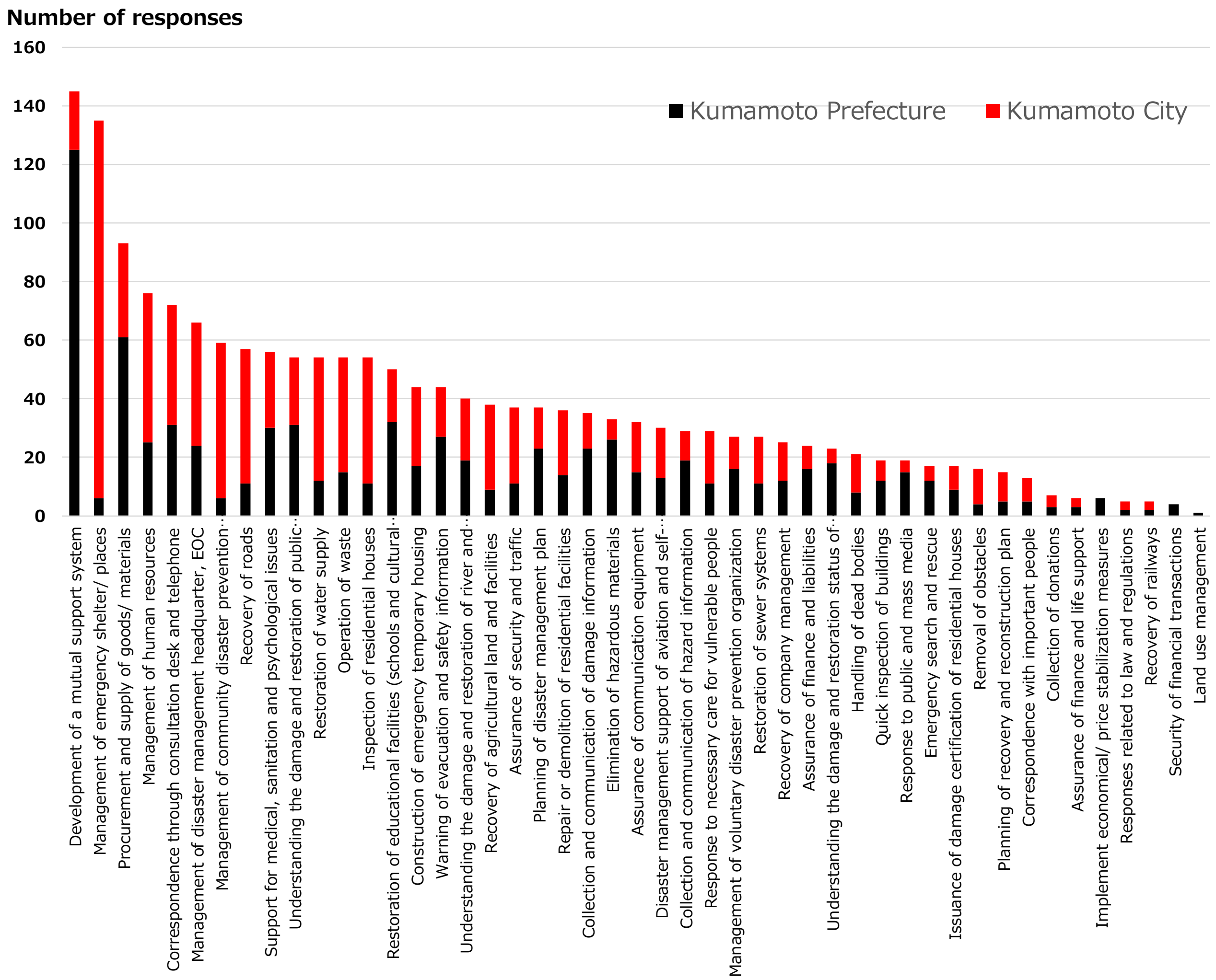
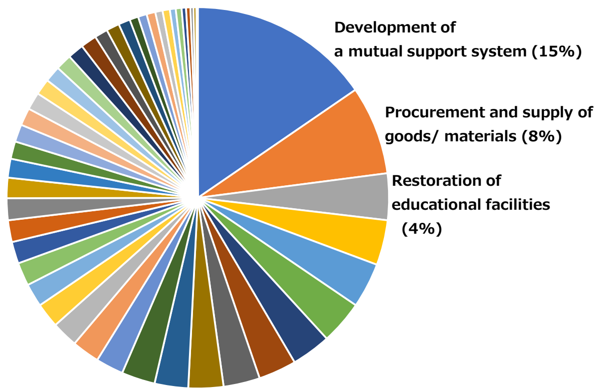
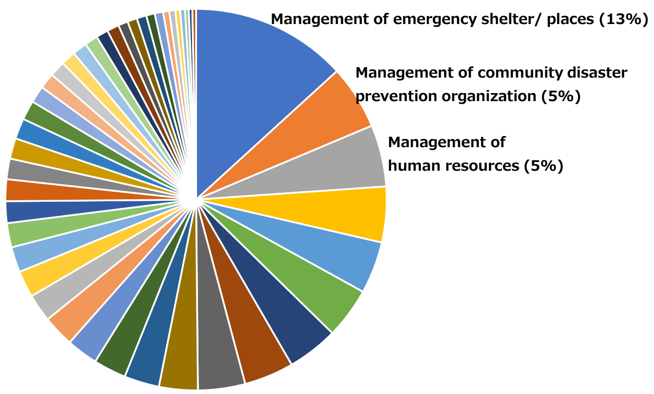


Fig. 11 Number of middle responses for the categories as for big process in Kumamoto prefecture and Kumamoto city



(a) Percentage of middle responses in Kumamoto prefecture



(b) Percentage of middle responses in Kumamoto city

Fig. 12 Percentage of middle responses for the categories as for big process

4. Training of BOSS

To use the BOSS in the disaster management, prefecture and municipalities are jointly trained by the BOSS. The scenario-based training is an active learning method with the BOSS. Fig. 13 shows the multi-visualization both prefecture and municipalities by the BOSS. Prefecture can monitor the contents of municipalities. Fig. 14 shows the post disaster mode of BOSS. The command of post disaster mode is used in the real disaster occurrence. In the post disaster mode, each response has checklists for understanding the important actions. About 150 kinds components as for the checklist are listed in BOSS for Prefecture level.

BOSS can be used to train the local government officials. Photo 1 shows the training for the local governments in Kumamoto prefecture. The results of training show the how to use the BOSS in daily work and real disaster responses.

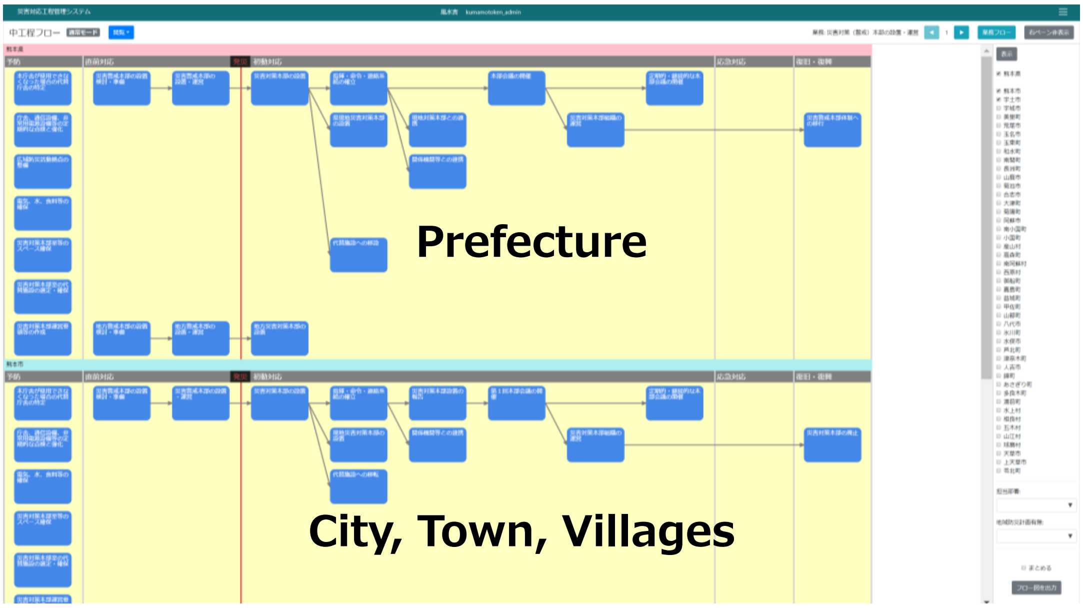


Fig. 13 Interface of visualizing both prefecture and municipalities (city town, villages)

(a) Post disaster mode (b) Checklist in post disaster mode

Fig.14 Post disaster mode shifting

Photo 1 Training in Kumamoto prefecture with municipalities

5. Conclusion

In the comprehensive disaster countermeasures, quick responses during an emergency phase are required a synergetic process, the developed BOSS (Business Operation Support System) effectively utilize available cross-sector collaborations to build on pre-determined strategic planning processes. Recognizing that resilient integrated data flows are a key factor in successfully managing disaster response and recovery processes, this system proposes to define the standard processes for a total disaster response management system. In this paper, the principal of BOSS and the system concept are described. 47 kinds of response category are frame worked to understand the completed disaster responses. The thick document of disaster manuals is managed by the BOSS for the effective management.

The next research of BOSS is to develop the function of numerical simulation of human resources and functional location management. The human resources are based on the workload of related disaster workloads. As for the functional location management, mapping of functions on the map in EOC to visualize the situation of allocated locations effectively to facilitate the vertical integration and cross-sector coordination by technology.

6. References

[1] M. Numada, S. Kondo, M. Inoue, and K. Meguro, "Analysis of Description of Local Disaster Management Plan for Smooth and Effective Wide-Area Support System During Large-Scale Disaster," J. Disaster Res., Vol.7, No.2, pp. 147-159, 2012.

[2] M. Numada and K. Meguro, "Macro Analysis of Initial Responses from Yabuki Municipal Government After the 2011 Tohoku Earthquake," J. Disaster Res., Vol.9, No.2, pp. 149-160, 2014.

[3] R. Kikuchi, M. Numada, M. Mon, T. Naing, K. Yu, and K. Meguro, "A Comparison of Disaster Management Plans for Both Japan and Myanmar," J. Disaster Res., Vol.13, No.1, pp. 62-69, 2018.

[4] M. Mon, T. Naing, M. Numada, K. Yu, K. Meguro, and K. Latt, "Analysis of Disaster Response During Landslide Disaster in Hakha, Chin State of Myanmar," J. Disaster Res., Vol.13, No.1, pp. 99-115, 2018.

[5] Muneyoshi NUMADA, Masashi INOUE, Kimiro MEGURO, "FRAMEWORK OF DISASTER RESPONSES BASED ON THE ANALYSIS OF THE 2011 GREAT EAST JAPAN EARTHQUAKE DISASTER, THE 2015 KANTO-TOHOKU HEAVY RAIN DISASTER AND THE 2016 KUMAMOTO EARTHQUAKE DISASTER", Journal of Japan Society of Civil Engineers, Volume 73, Issue 4, pp. 258-269, 2017.

