SESSION 2: Risk assessment and management/ Risk Analysis Simulation Techniques

议程二：风险评估与管理/风险分析模拟技术

基于社会力模型的一个通道的双向人流研究

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【摘要】我们运用 Dirk Helbing 的社会力模型，构建一个程序来模拟在走廊的双向人流，并进行了一个现实实验来验证它的正确性。仿真结果显示在宏观层面的两种流动运动趋势，并提供在堵塞时，关键的密度和速度。在分析了速度、密度和走廊的宽度之间的关系后，我们可以预测变量条件的人流堵塞事故点，这将有助于优化结构设计走廊潜力。

首先，我们建立一个基于社会力模型的程序，在这个程序中走廊主要的参数可以被控制，走廊的长度和宽度、双向人流的密度，柱的存在和放置。不同的周边环境能被赋予参数，在整个仿真过程中所有的数据和图表能被记录，如密度、速度、独立和整个人流。根据结果，我们能发现走廊中双向人流的特性，最终表达一个优化的工程去快速疏散以降低阻塞事件。

此外，我们在休息时的教学楼大厅建立类似走廊的情况，记录了学生流有无障碍物的视频记录。通过模拟结果和真实实验数据对比，我们证明了模拟的准确性和完善方案的参数值。最终，速度，密度，压力和走廊的宽度的统一关系将被确立。该仿真方案的最后结果应该有助于指导高密度双向流动走廊和疏散路线的设计。

【关键词】双人流；通道；社会力模型；仿真

STUDY OF BIDIRECTIOANAL PEDESTRIAN FLOWS IN A CORRIDOR BASED ON SOCIAL FORCE MODEL

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Keywords

Bidirectional Pedestrian Flows, Passage, Social Force Model, Simulation

Abstract

With Dirk Helbing’s Social Force Model, we created a program to simulate bidirectional pedestrian flows in a corridor and conducted a realistic experiment to verify the exactness of it. The result of simulation showed macroscopic level of the trend of two flows movement, and provided the critical density and velocity when clogging emerged. After analyzing the relations between velocity, density and the width of corridor, we could predict potential congestion accident point in variable conditions of pedestrian flows, which would help optimize the design of corridor structure.

First of all, we established a simulation program based on Social Force Model, in which primary parameters of the corridor could be regulated, such as the length and width of the corridor, the density of two pedestrian flows, the existence of columns and the placement of them. Different circumstances could be realized with those parameters, and all data and charts during the whole simulation could be recorded, which were densities, velocities and pressures of both individuals and the whole flows. According to the result, we became able to discover the characteristics of bidirectional pedestrian flows in a corridor, and finally formulated an optimized project to evacuate much more quickly so as to reduce the risk of congestion accidents.

Besides, we constructed a similar corridor situation at the teaching hall during breaks, and took a video record of student flows with and without obstacles. Through comparing data between the simulation result and the real experiment, we testified the accuracy of the simulation program and perfected the values of parameters. Ultimately, a unified relation between velocity, density, pressure and the width of corridor will be established. The final result of the simulation program was supposed to help guide the design of both high-density-flow corridors and evacuation routes.

Introduction

With the rapid development of cities, the issue of pedestrian traffic is becoming increasingly severe. It has been the primary problem that how to design rational and effective transport facilities to ensure the safety and efficiency of pedestrian flows, especially in the accelerating process of urbanization and large-scale events been held. There have been new demands for diverting pedestrian. Among pedestrian traffic simulation models, the social force model is one of the most famous and effective one. After observations, we find that the theoretical model of social forces don’t contain one-side orientation, which is obviously normal in the real world. This has resulted in the deviations of observation and simulation results.

By comparing the actual situation of pedestrian passages and the social force model, we proposed an improved method, and conducted simulation and analysis of a two-way straight passage with pedestrians.

Theory

To verify the accuracy of observation, we choose the Social Force Model in the simulated scene.

Social Force Model

It is suggested that the motion of pedestrians can be described as if they would be subject to ‘social forces’. These ‘forces’ are not directly exerted by the pedestrians’ personal environment, but they are a measure for the internal motivations of the individuals to perform certain actions (movements). The corresponding force concept is discussed in more detail and can be also applied to the description of other behaviors.

In the presented model of pedestrian behavior several force terms are essential: First, a term describing the acceleration towards the desired velocity of motion. Second, terms reflecting that a pedestrian keeps a certain distance to other pedestrians and borders. Third, a term modeling attractive effects. The resulting equations of motion are nonlinearly coupled Langevin equations. Computer simulations of crowds of interacting pedestrians show that the social force model is capable of describing the self-organization of several observed collective effects of pedestrian behavior very realistically.

According to the nature of this scene, some improvement was created to the social force model.

The corridor length was 60D, pedestrian have access on both sides of the entrance by a random place to enter. All size is measured by the element of diameter D as one unit.

Based on actual observations, we added the character of right orientation to pedestrians in the simulation. Namely, in force analysis, if found that the person was in the left hemi-passage, there would emerge a self-driven force of orientation f_{ori},

$$f_{ori} = a_{ori} \cdot f_{spi}$$

$$a_{ori} = c(1-\frac{y_i}{Y_w}) \text{（Left entry）或 } a_{ori} = c\frac{y_i}{Y_w} \text{（Right entry）}$$

Where f_{ori} is proportional to the self-driving force and positions of pedestrians in the corridor, and the direction is to the right side of the pedestrian. In the simulation valuing c = 0.5.

Method

1. Observation records in the bi-directional straight corridor

We conducted actual observation and measurement in an open corridor between two school buildings in Shanghai Jiao Tong University Minhang Campus. Corridor width was 3.2m. Camera observation area was approximately 12m × 3.12m. Pointing and tracking by cameras filming, filming time was December 7, 8, 11 and 12-day 9:40-10:00 and 15:40-16:00. The average temperature was 11.5℃, and the average age of pedestrians in the observation is 20. All video data was inputted into statistic software. Depending on the ground grid size 0.305m × 0.215m, and the length of the wall line spacing 3.66m, we used the video timeline to calculate the speed of pedestrian trends in crowded conditions, and by changing passage width in order to establish pedestrian speed and passage width relationship.

Figure 1 two-way flows in the straight passage

According to Roytman observation, the human body width of the left and right is 0.5m, and that of the front and rear 0.32m. Since the observation is winter, while students were generally carrying bags, we valued both the width of the left and right and that of the front and rear 0.5m. Because of the intermittency in flows, the density ranged between 0 person / m2 and 2.5 people / m2. Pedestrians flowed normally and orderly without panic or sent packing phenomenon, and when the density was greater than 1, the flow showed the nature of the right orientation.

Within the period of the density of 1-2.5 people / m2 when the two-way flow of people could fully touched and rubbed, we carry out observation and recording of flow velocity. In different corridor widths, sampling and analysis of walking speed for different target groups, Figure 2 shows the relationship between speed and passage width of the scatter and the average curve, in which the width of the passage to the diameter D = 0.5 persons as a unit.

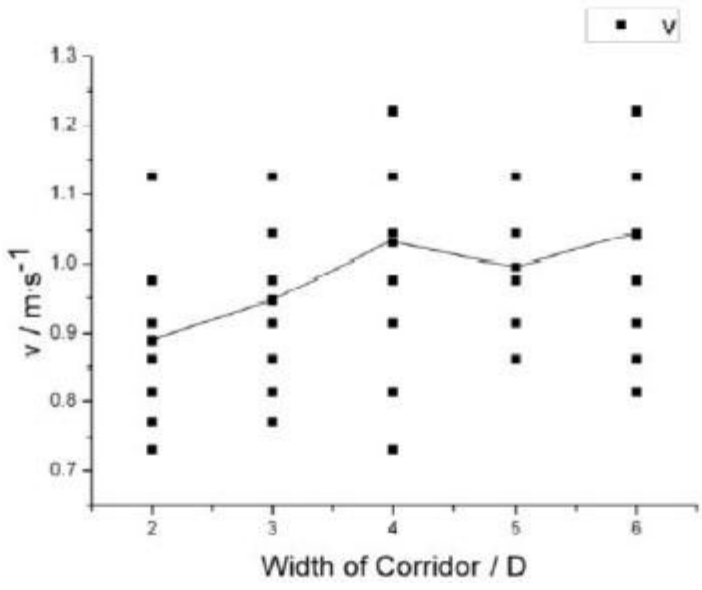

Figure 2

In different passage widths, pedestrian average speed is 0.987m / s. In the passage width for the 4D and 6D there is a maximum speed of 1.126m / s; passage width for the 2D, a minimum speed of 0.732m / s come forth. It‟ s can be concluded from the velocity distribution that the pedestrian average speed increases as the passage width increased, but it‟ s a non-linear relationship with smaller rate.

2. Simulation of pedestrian flows with right orientation in the bi-directional straight corridor

2.1 Simulation of intermittently-entering flow

Figure 3 is the curve of the average speed of two-way pedestrians over time after adding the right orientation, where the number of pedestrians was 50 on both sides to ensure that all pedestrian could approach the entrance before there was someone leaving the corridor, the width of which was 4D.

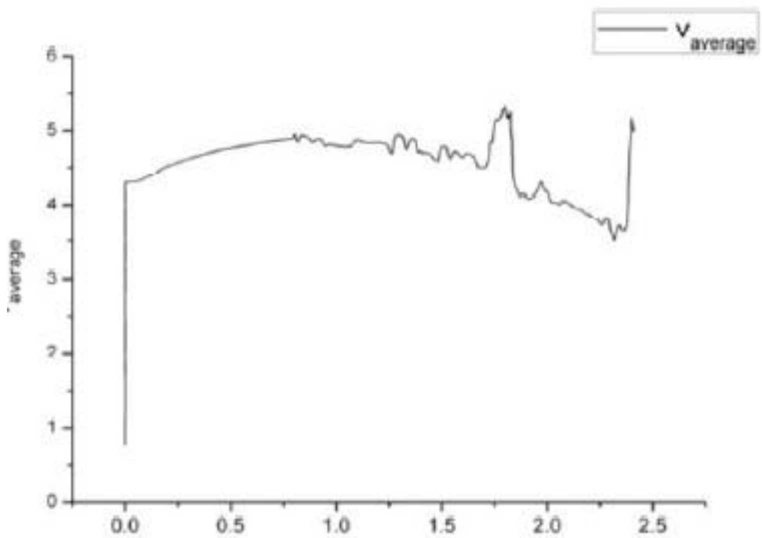

Figure 3

The speed increased rapidly after both sides of the pedestrians entered the passage, and they tended to gradually get into their hemi-passage under the force of orientation. Provided by the simulated images, it appeared that in the social force model, the number of pedestrians in parallel increased with the widening of the passage. When the bi-directional flows of people got into the middle of the passage, which was the range of social force, the average speed started to decline, as well as the curve showing significant fluctuations. The main reason is that the repulsive and friction force produced by two-way flows of pedestrians changes both the speed and position of pedestrians, and a few of them haven't entered their respective right hemi-passage, resulting in collisions with those head-on. A small range of friction or collision slows down the speed, but helps rebuild the system of orderly passage with one-side orientation, while serious frontal impact will be significant reduction in traffic speed, even cause some disorder in the flows. When some partial disorder occurs, pedestrians can be easily injured by excessive force. If we didn't change the value of the orientation force or the direction, it is difficult to return to an orderly state.

In the two-way flow convergence process, the average speed had a large fluctuation, that is, the peak in Figure 3. This is due to a new disorder within the two-way flows of people in complete contact. Since the passage is narrow, based on the Pressure Door theory, the party with larger pressure initially breaks the congestion of the opposing one, which reflects the nature of pedestrians as "fluid". As the initial pressure gradually reduced the number of the larger party, the pressure decreased, which led to re-formation of congestion, that is, the rapid decline of the speed after the peak and the subsequent slow decline in the figure. The role of the orientation force faded in the post-peak period, and the two sides of the passage slowed down. There reflected no more influence of orientation force until no congestion existing in the process.

2.2 Simulation of continuously-entering flow In the case of continuous flows into the passage, another serous bottleneck appeared on both sides of the entrance after we adding the right-side orientation in the bi-directional passage, that the situation reflected in Figure 4. Figure 5 is a two-way average speed of pedestrians over time curve, where the number was set as 400 on both sides to ensure that there were still pedestrians getting into the passage when pedestrians stared to leave through the target exit as a constant flow. The passage width was 10D.

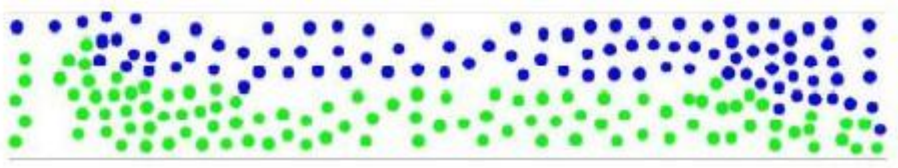

Figure 4

In the design of simulation, pedestrians entered the passage at a random location on both sides. When a pedestrian got near the target exit, which was the entrance of the opposing ones, a head-on collision was unavoidable between the two-way flows of people. According to the pressure of pedestrian theory (literature), as the front part of the flow faces resistance encountered by the front, the speed will be seriously reduced, and a large number of pedestrians were waiting for the over-passing, which resulted in a sharp increase in the force of the front pedestrians, and casualties easily occurred. In Figure 5, the intermittent reduction of the average speed reflects the impact of frontal collision between the pedestrians in the target exit and the opposite-side pedestrian at the exit.

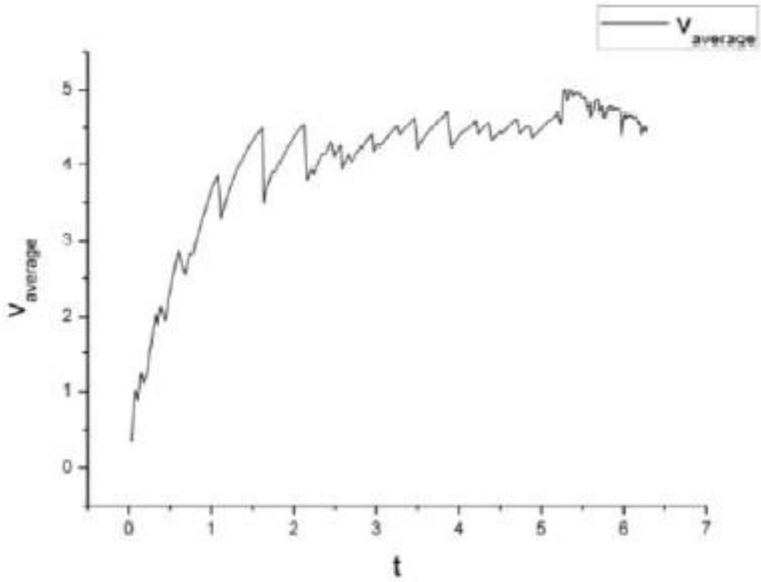

Figure 5

More seriously, about 50% of pedestrians were pushed away by the flow of opposing people at the entrance, resulting in decrease in the flow of people inside the passage. Although the average curve does not clearly shows this phenomenon, considered the evacuation function of passage, this kind of collision at the entrance still significantly reduced the passage efficiency.

3. Social force model simulation analysis

Figure 2 is the scatter diagram recorded from the observation, which represents the relationship between the width of the passage and the average speed of two-way pedestrians, while Figure 6 is the curve of the average speed in the Social Force Model. The two curves of average speed in both observation and simulation are of the similar shapes, which indicates the simulation effect is good. From the scatter diagram, we can undercover a small proportional relationship between the average speed of pedestrians and channel width, but it is not closely related.

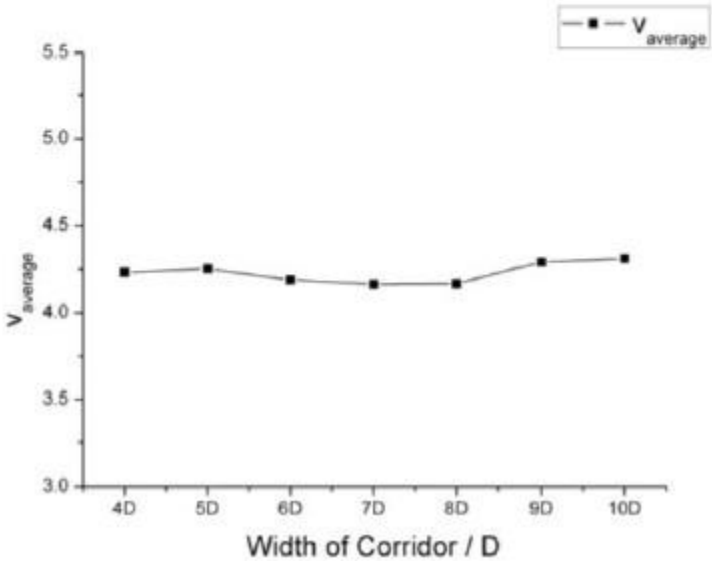

Figure 6

From the social force model analysis, we find the friction produced by walls and opposing pedestrians to be the direct cause of the slowdown of the walking speed if pedestrians always maintain one-side orientation when passing the corridor. The average speed can be expressed as

$$v_{average} = \frac{\sum_{n} v_d - c\cdot(f_{fw} + f_{fij})}{n} = \overline{v}_d - \frac{c\cdot(f_{fw} + f_{fij})}{n}$$

Where, v_d for initially self-driven speed, n for the number of people in parallel in passages of certain width, f_{fw}, and f_{fij} were the walls and pedestrian friction. Under different channel widths, the value of the friction is almost of no change.

When the channel width increases, n (the number of pedestrians in parallel) may increase, as well as the pedestrian average speed with a decreasing growth rate.

Results and discussion

1. Conditions for the occurrence of one-side orientation in two-way straight passages

Although there's no walking restriction on both sides of the zebra crossing, there are few pedestrians cross over it, and they can enter or exit the zebra crossing freely and randomly. So we choose zebra crossings as the observing object to record and simulate.

From the video record we can find that the fluid nature of pedestrians was reflected clearly, but it is not the case for right-side orientation tendency. The whole intersection was almost occurring in disordered state. Compared with the normal channel, zebra crossings is a channel object with the characters of strong intermittent flow and shorter channel. The two-way intersection was filled with direct frontal contacts, and the body shape of pedestrians would change when passing the opposing ones. In the simulation it is not appropriate to use a circle representing a pedestrian. Moreover, the range of force has greatly narrowed, and the mutual repulsion is significantly less than the friction. There has been a great deviation between the result of simulation and the observation when the social force model is applied in this scene. Without the right orientation, the simulation will be severe congestion, rather than the observed rapid passing of pedestrians through the intersection. Therefore, a passage with characteristics of zebra crossings is suitable for analysis in Active Walker Model rather than Social Force Model. But for such passages, pedestrians can often use a more flexible passing approach, rather than the policy of forming an orderly flow.

Pedestrians will choose depending on the situation in the channel, if they will be in contact with the surrounding crowd for a long time, or the channel is comparatively long, they will choose to enter the pedestrian flow of the same direction to reduce the frictional resistance, as well as the frontal collision with the opposite pedestrians. If there will only be a short contact with the opposite flow of people, then the pedestrians will not easily show any tendencies, and there is also a greater change in force status.

2. Strategies for improvement of passage efficiency

Pedestrians generally have right-side orientation tendency when actually walking in passages, and right-side orientation tendency will ultimately lead to a higher pace of an ordered two-way flow of pedestrians, especially in the process of long saturated pedestrian flow.

Therefore, in the social force model, aside from the simulation of the behavior in one-way direction and in panic situations, left or right-side orientation force fori should be added according to the actual characteristics of pedestrians in order to achieve to improve the accuracy of the simulated experiments.

The relationship of the average pace of the pedestrians in a straight channel with right-side orientation tendency and the width of the channel is: When the width of the channel is comparatively small ($0 < d_w < 4D$), When the width of the channel is comparatively small ($0 < d_w < 4D$), the average speed of pedestrians increases more obviously as the width of the channel increases; when the width is larger ($d_w > 4D$), the average speed of pedestrians hardly changes with the channel width.

When two-way pedestrians with one-side orientation are getting through the passage, the main factor affecting walking speed is the collision towards the opposing pedestrians. Although in real world people can make judgments in advance to decide to halt or change the direction of velocity and very few collisions happen, but the speed of flows would be affected as same as the simulation in social force Model. In addition, once a collision caused disorders in the passage, it was difficult to form an orderly flow of people again if no orientation force was added or changed. Therefore, there should be set up barriers to reduce the impact of opposing pedestrians on the flow rate, and we can also play radio or establish signs to strengthen the pedestrians' consciousness of orientation of the left or right side.

For a straight two-way passage with sustained flow of people entering, the speed bottleneck occurred at the entrances at both ends. Without restricting the position of pedestrian entering the passage, frontal collision can easily lead to difficulties for opposing pedestrians to leave the passage, resulting in slowdowns of the velocity and flow rate. Therefore, to ensure the smooth at both ends of the passage when there is one-side orientation tendency, there should be placed barriers to divert pedestrians into and out of the entrance, which can help two-way flow of people entering and leaving freely without interference.

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组织应急管理能力评价工具

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【摘要】紧急状态下良好的应急管理能力在受灾组织和地区已倍受关注。一个在研的瑞典多学科研究子课题针对包括发展和提高组织的适应力和应急能力有潜在重要性的区域或过程的确定问题进行研究。本文阐述了从引导会谈到区域和过程确定的一些初步发现，并提出使组织能够持续评估和发展他们组织应急管理能力的方法。会谈由来自瑞典区域共同体的四个不同部门的代表举行。初步结果表明当评估组织应急管理能力时，应该包含以下区域和关键过程：现有组织应急能力评估，风险和易损性分析，能力储备，操作能力、预警机制、行动通讯、安全培训和组织培训、领导和管理、个体和组织认知能力等。本文提出的能力的自我评估方法是基于包含五个从低到高成熟等级的成熟模型，一个组织通过能力建设和从上一阶段中去掉响应的不足来逐级向上发展，每个成熟水平是基于如何使组织对新知识和经历的认知和反应来描述的。每个区域和过程是按照五个成熟等级来描述，自我评价按照一个组织内发生的前期准备行动的分析，讨论和反思来进行准备的。

【关键词】应急管理；能力评价；　能力成熟标准

TOOL FOR EVALUATING ORGANIZATIONAL EMERGENCY MANAGEMENT CAPABILITY

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Keywords

Emergency management, capability evaluation, capability maturity level.

Abstract

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Crises or emergencies have drawn attention to the need of good emergency management capability in affected organizations or regions. An ongoing subproject in a Swedish multidisciplinary research programme aims at identifying areas or processes that are potentially important to include in the work of developing and improving an organization's resilience and emergency management capability. This paper presents preliminary findings from interviews conducted to identify such areas or processes and proposes a first version of a methodology that can enable organizations to continuously evaluate and improve their organizational emergency management capability. Interviews were conducted with four representatives from different administrations within a regional public body in Sweden. Preliminary results show that when evaluating organizational emergency management capability, areas or key processes such as the following ought to be included: assessment of existing organizational emergency management capability, risk and vulnerability analysis, competence provision, operational surveillance and alarm functions, operationalization, communication, safety culture and organizational culture, leadership and management, individual and organizational learning. The proposed methodology for self evaluation of capability is based on a maturity model containing five maturity levels, low to high. An organization develops in stages upwards through the levels by building on the strengths and removing the weaknesses from the previous level. Each maturity level is described based on how the organization learns and reacts to new knowledge and experiences. Each area or process is evaluated and described according to the five maturity levels. The self evaluation provides for analyses, discussion and reflection concerning the proactive management activities taking place in an organization.

Introduction

Crises or emergencies are unexpected events that may strike any sector of society and any type of organization. The causes are often complex in nature. Recent events have drawn attention to the need of good emergency management capability in affected organizations or regions. The current focus of emergency management capability is on the proactive and systematic work of reducing risks and uncertainties in an organization and on the everyday preparation for the managing of potential crises or emergencies. Research on emergency management has shown that there can be many deficiencies in the preparations and planning for emergencies, and that efforts should focus on promoting resilience (Boin and McConnell, 2007), which is the capability to keep processes within safe limits and, when needed, the capability to bring operations back to a safe state after disruptions.

In a Swedish multidisciplinary research programme, FRIVA (Framework Programme for Risk and Vulnerability Analysis), a subproject has focused on identifying areas or processes that are potentially important to include in the work of developing and improving an organization's resilience and emergency management capability. The research has also aimed at proposing a methodology that can assist large organizations in continuously assessing and improving their organizational emergency management capability.

In order for these efforts to be proactive and successful, it is vital to have a continuous evaluation of processes essential for this capability. These evaluations should be systematically performed and supported by a management system. Such a system can contain goals, plans for development, actions, and evaluation for each area or process considered important to include. There may be a need to assess specific areas or processes separately, as well as to do a more comprehensive evaluation of the overall emergency management capability of an organization. Through the evaluation, process development activities can be guided towards a more robust, efficient and resilient organizational performance. When emergencies arise, the organization itself stands better prepared and connected to the surrounding world.

Aim of the paper

This paper (i) presents preliminary findings from interviews conducted to identify areas or processes that can be potentially important to focus on when developing or improving the emergency management capability in an organization; (ii) proposes a first version of a methodology that can enable organizations to continuously evaluate and improve their organizational emergency management capability.

Theory and Method

Interviews were conducted with four representatives from different administrations in the southernmost regional public body in Sweden. The interviewees were: the traffic unit manager of the public transport administration responsible for city and regional buses and trains; the co-ordinator of the property management administration (for properties owned by the regional body); one of two disaster co-ordinators of a university hospital; and the medical unit manager of the emergency room at the same university hospital, who was also chairman of the disaster committee.

The interviews aimed to identify areas or key processes that are considered necessary when evaluating organizational emergency management capability. The interviews also provided information and knowledge about each administration's core activities, their existing safety and risk management processes, and their continuous improvement work.

A literature review on the topic of emergency/crisis management capability as well as on capability maturity models was also conducted to support and complement the information gained through interviews.

Results – areas of importance for emergency management capability

Preliminary results from the interviews and literature review show that when evaluating organizational emergency management capability, areas or key processes such as the following ought to be included: assessment of existing organizational emergency management capability, risk and vulnerability analysis, competence provision, operational surveillance and alarm functions, operationalization, communication, safety culture and organizational culture, leadership and management, and individual and organizational learning.

What follows is a description of the identified areas.

<u>Assessment of existing organizational emergency management capability</u>

Ideally, the organization should thoroughly and continuously examine how well it works with developing and adapting its emergency management capability, and use the findings to make improvements. On a more concrete level, there is a need to establish aims and goals, to analyze or assess associated needs, and to examine how well these needs are met. This process can be performed more or less systematically and with varying degrees of integration with other processes, which in a maturity model corresponds to different levels of process maturity. The current needs can be identified in part through risk and vulnerability analyses or analyses of past emergencies and incidents. These analyses may provide good advice on probable future needs for resources in emergency management and for dimensioning activities to strengthen the capability. They may point to opportunities to decrease or eliminate risks. Results from the analyses should also affect emergency management planning, education and training.

<u>Risk and vulnerability analysis</u>

Substantial attention should be put on proactive efforts that aim to find and examine risks and vulnerabilities concerning the organization's mission, the activities in the organization and its basic conditions (ISO/PAS 22399:2007). The risk and vulnerability analysis process aims at understanding these two aspects of the context in which the organization is working, and should be performed integrated into regular work processes. The systematic analyses entail data collection and analysis of information on, for example, system and procedural weaknesses, latent conditions on different organizational levels, available resources and competence.

<u>Competence provision</u>

The competencies an organization needs to successfully perform its activities and operations, its emergency management, and to develop its emergency management capability need to be mapped out. Competence not only involves the knowledge, experience and capabilities of the individuals, but of the entire corporation.

Input to the competence provision can be gained from the risk and vulnerability analyses, analyses of past emergencies and events and above all the managing of them. Methods for developing and ensuring access to competence include recruiting, education, training or obtaining equipment.

Operational surveillance and alarm functions

To protect an organization, or that which the organization is to protect, it is necessary to detect as soon as possible threats to and deviations from normal operations. This enables swift deployment of actions to minimize the degree and duration of disruptions and strains, which may decrease suffering as well as costs. Therefore, a function is needed that constantly monitors the state of operations and intercepts possible signals about rising threats.

Emergency response requires the recognition of an emergency and the initiation of response activities. That, in turn, necessitates a state of continuous readiness that is able to initiate emergency response actions. In cases of imminent threat to operations, or disturbances of operations that are in progress, such a monitoring function should initiate an adequate organizational response.

How a surveillance process and associated alarm function should be manifested varies depending on organizational size, operational activity, and tasks and methods concerning emergency management. Sometimes different levels of alert may be appropriate, so that the initial attention to a potentially critical situation does not necessarily result in the initiation of vast response activities. Sometimes it is more appropriate to let a group monitor a developing situation and decide if and when emergency response operations are to start. It is important to remember to maintain watchfulness for other threats that may arise in parallel with the first.

Operationalization

Operationalization in this context means the ability to go from written plans, goals and operation plans to concrete action and the implementation of written plans. There is a need to concretize planned activities. In relation to emergency management capability, this activity can be specific or more comprehensive. Operationalization of the emergency management plan is fundamental: to be in possession of only one is inadequate (Pollard and Hotho, 2006). The plans need regular revision and systematic testing. Simulations and scenario exercises yield important information that can lead to continuous updating of plans and even better operationalizations.

Operationalizations can also be more comprehensive in an organization. Organizations that are more prepared for crisis relates to having a stronger ability to integrate crisis/emergency management and strategic implementation strategies (Pollard and Hotho, 2006). An integrated strategy makes it possible that emergency management, as well as emergency management capability, become a process with an implementation strategy.

Implementation or an operationalization in an organization always means that a change takes place and for the change process to be successful, it has to be managed efficiently regarding content, people and processes (Kaarstad and Heimdal, 2005). An ability for operationalization (i.e. carrying out written plans) requires that persons with different knowledge and competencies are involved in the implementation. Flexibility is also needed which allows people with the right competence but perhaps with a lower rank in the organization to solve a problem. This means that the organization is able to temporarily become flatter, and when the problem is solved, go back to its original (and often) more hierarchical form. For example, in emergency treatment it has to be possible for doctors to climb up and down the hierarchy level, the first day functioning as the head and the next as doctor. Co-workers in the work setting must be able to accept that the same person takes on different roles.

Communication

Awareness of the key role of communication is fundamental. Effective communication and employee involvement are practices that best drive organizational changes forward. The practices that hinder change the most are failing to communicate to all employees about change, not articulating the change vision, or being dishonest (Greenbaum et al., 1998). Communication should thus be managed more strategically as a corporate process. An administrative plan for communication vertically, within and between parts of the organization needs to be made clear.

Poor communication can have its origins in insufficient openness or an unawareness of other organizational members' needs for information and communication. Through education these needs can be clarified and attitudes changed, but above all, an overall picture and understanding of the activities in the organization can be created. Co-workers need to have such an overall picture and be aware that individuals are important communication links in creating this systems view. Education can also highlight the transmitter/receiver/dialogue perspectives and increase motivation and employee involvement.

Good communication and listening skills across groups and individuals can achieve a shared situational awareness with respect to risk and safety. Mearns et al. (2001) suggest that conflicts of opinion and misunderstandings between subcultures and individuals can often be precursors to accidents and incidents. Good communication can prevent errors and also catch and mitigate errors. A diversity in safety attitudes can be beneficial, as subcultures can bring new perspectives 'that can provide a forum for learning, innovation and development' (Mearns et al., 1998).

In addition, establishment of links with the media is vital for good communication with the public.

Safety culture and organizational culture

It has been shown that the most important factor regarding the behaviour of organizations before, during, and after major crises is the character of the collective mind (Udwadia and Mitroff, 1991), which is expressed here as the existing organizational cultures. It has often been pointed out that the organizational culture shapes the safety culture (i.e. the attitudes, values and perceptions regarding safety and safety work that individuals and groups in the organization have). Individuals' behaviour in relation to risk and safety is also an important part of the culture. Sometimes a safety culture is recognized as one that is reporting and just (i.e. the organization has succeeded in creating trust between involved parties leading to the fearless reporting of risk and safety related incidents and anomalies with a will to make improvements).

The safety culture is very much affected by the commitment to safety that the leadership in the organization has and shows.

Leadership and management

The leadership and the way to lead shape the foundation for how efficient and successful the work will be performed in an organization. Factors such as organizational structure and distributed power of decision can also affect the performance. As mentioned, resilience is a characteristic worth striving for in the daily work of preventing and preparing for crises and emergencies. Leaders can facilitate resilient responses and behaviours when an emergency emerges if beforehand they, for example, have created expert networks, trained for situational and information assessment, learnt how to support and facilitate emerging nodes of co-ordination, organized outside forces, and worked with the media to provide a crisis rationale (Boin and McConnell, 2007).

Individual and organizational learning

Good organizational learning is considered important for successful organizational development and improvement efforts related to several areas such as safety, risk management, and productivity. Learning is a process that starts with the detection of a potential problem, continues with an analysis and assessment of the problem to identify feasible solution options, is followed by the selection of an adequate subset of these options and ends by implementing these in relevant operations (Koornneef, 2000). Organizational learning cannot be taken for granted, because organizations can only learn through people (Argyris and Schön, 1996). For organizational learning to take place, the individual must notify a learning agency. Such an agency consists of people with adequate explicit and implicit knowledge about current operational processes. The learning agency needs to be linked to management, which have the power to make decisions that can change the conditions, goals or resources of the work processes (Koornneef, 2000). In many activities such an agency for learning is missing.

For good learning to take place in relation to safety and risk management a close link is emphasized between the risk assessment process (which specifies existing risks), the risk management process (which establishes risk controls), the operational process (which carries out the controls), and the learning process (which assesses and improves the controls) (Koornneef and Hale, 2004).

Knowledge management

Strong and well-developed possibilities for knowledge management can increase an organization's emergency management capability. Strong needs can exists for having robust mechanisms for communication to facilitate information and knowledge exchange and to disseminate best practices. To achieve an effective knowledge management, support for communication, knowledge sharing and learning, co-operation, co-ordination and social interaction needs be developed and stimulated within an organization (Andriessen, 2003).

Results – evaluation of emergency management capability based on a maturity model

A first version of a methodology for evaluating an organization's emergency management capability is presented here. In order to have proactive and successful measures for improving emergency management capability, it is vital to have a continuous evaluation of the processes essential for this capability. These have already been presented. A recurrent evaluation of these processes creates opportunities to find strengths and weaknesses in the organization and show where resources need to be put to strengthen weak parts.

The self evaluation is carried out by use of the Emergency Management Capability Maturity Model (EMCMM). The model contains five maturity levels, low to high; an organization develops in stages upwards through the levels by building on the strengths and removing the weaknesses from previous levels. Each level is described based on how the organization learns and reacts to new knowledge and experiences (Strutt et al., 2006), see Figure 1.

The process orientation gives an overall picture and an aspiration for long-term improvements and solutions. The evaluations should be carried out systematically by, for example, stating goals and plans for the development of each area or process, action plans and evaluations plans, as well as a distribution of responsibilities for the actions.

Each process or area is evaluated and described according to the five maturity levels. The self evaluation provides for analyses, discussion and reflection concerning the activities taking place in the organization. It is important to provide feedback of the results to the organization. For each process, a vital focus is the transition between the maturity levels in the model: how to improve, what type of learning processes exist, how they can be developed and improved, when 'good enough' is reached, and how to remain on that level.

Improving emergency management capability

Optimizing: The organization applies 'best practice' and is capable of learning and adaptation. Experience is used to rectify problems and the organization can change its way of working to achieve better emergency management capability. Adaptive double loop learning.

Managed: The organization has control of its performance and has defined processes. It sets (quantitative) goals and ensures that they are met through feedback. Single loop learning.

Defined: The organization can describe its work and how it is performed, but finds it difficult to use output from processes to affect emergency management capability.

Repeatable: The organization can repeat earlier work but not describe what it is doing. Processes are not properly defined and lack real effect on emergency management capability.

Initial: The organization has limited experience and is at an early stage in development. Processes are not standardized and mainly uncontrolled. Learning is reactive.

Figure 1. Maturity levels when evaluating organizational processes important for emergency management capability (inspire by Strutt et al., 2006).

Discussion

This paper has focused on organizational processes found in interviews to promote resilience and emergency management capability. A first version of a methodology for self evaluation of an organization's capability maturity was also proposed.

All interviewees recognized the different organizational areas and key processes presented in the paper as important for emergency management capability. The interviewees worked at different administrations in a regional public body in Sweden: public transport, property management, university hospital emergency ward medical unit, and disaster co-ordination. Depending on the type of organizational activity, some processes were extra highlighted as important. For example, in the public transport administration (trains and buses) the communication (and information) process was found to be especially vital for their normal activity and therefore also for their emergency management capability.

Successful risk and safety management emphasizes the proactive approach to finding weaknesses and anomalies in an organization. Reactive methods are important, but combined with proactive methods, a stronger management can be achieved. Above all, higher capability requires proactive as well as reactive approaches. The self evaluation of emergency management capability provides the opportunity to work in a proactive manner and continuously evaluate and improve the capability.

However, the existing attitudes, commitment, and resources to work proactively in an organization often depend on the existing safety culture and organizational leadership. Sometimes increased awareness needs to be achieved as well as knowledge about the importance to have a systems view on risk, safety, and emergency management.

For organizational learning to take place, individuals that have gained insight on how to perform a work process more efficiently or have experienced a problem, must in some way notify a learning agency (for example through a written report). In some organizations, such an agency can be ill defined or lack proper knowledge and resources to perform good analyses for learning and improving the capability. Nevertheless, several of the areas or processes that were put forth in the paper as important for emergency management capability are also important for the general normal activities that take place in an organization. They need to function well in order to yield effective normal daily work, which means that the cost for thinking in terms of an emergency management perspective need not be so high.

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动态人口建模

GIS VERSUS REMOTE SENSING – A CASE STUDY FOR ISTANBUL

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【摘要】过去十年里，世界人口的快速增长涌现了很多人口过百万的大城市，1999 年土耳其的 Izmit 地震是自然灾害对大城市影响的一个典型例子。1999 年 8 月 17 日，土耳其的 Izmit 发生了 7.6 级大地震，20000 人遇难，经济损失 6.5 亿美元。在未来 30 年里伊斯坦布尔市发生 7 级左右地震的概率为 30～70％，未来减少自然灾害对人类生命的威胁和影响，灾害应急管理计划是关键。这些计划的发展变更很大程度上是基于最新的人口数据，然而现有的人口统计技术不能满足当今城市人口动态变化的需求，过去几年里遥感技术成为一个重要的信息源，然而，对于遥感应用于城市统计的可用性仍然缺乏理性的分析和讨论，本文利用 IKNOS 卫星影像对土耳其伊斯坦布尔的 Zeytinburnu 地区进行人口数量估计建模可行性研究，结果表明 IKONOS 影像能够用来对现有人口数据进行补充，单一建筑物的自动提取可以作为人口估计的主要误差源。另外本文还进一步对其优势和局限性如综合成本等进行了讨论。

【关键词】人口估计；建立清单；应急计划；遥感；伊斯坦布尔

MODELLING OF POPULATION DYNAMICS:

GIS VERSUS REMOTE SENSING – A CASE STUDY FOR ISTANBUL

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Keywords

Population estimation, building inventory, emergency planning, remote sensing, Istanbul

Abstract

Over the last decades, the rapid growth of the world population has led to a large number of emerging megacities. The 1999 Izmit (Turkey) earthquake is a striking example of the impact of natural hazards on megacities. On August 17 1999, a magnitude 7.6 earthquake struck the area of Izmit in Turkey, causing about 20.000 fatalities and US$6.5 billion economic loss. The probability of a magnitude 7 earthquake striking Istanbul within the next 30 years ranges between 30% to 70%. In order to reduce the impact of natural hazards on human lives, emergency management plans are essential. The development of these plans strongly relies on up-to-date population and inventory data. However, existing techniques for population data generation do not meet the requirements of today's dynamic cities. In this context remote sensing has become an important source of information in the last years. However, a rational discourse on the suitability of remote sensing for urban applications is still missing. In this study a quantitative evaluation of the suitability of IKONOS imagery for population modelling using the district of Zeytinburnu (Istanbul, Turkey) is conducted. The results reveal that IKONOS images can be used for complementing existing inventory data set. The automated extraction of single buildings was identified as the major source of error in the population estimation. Further advantages and limitations such as the associated costs are discussed in this present paper.

Introduction

Over the last decades, the rapid growth of the world population has led to dynamic and complex urbanization on a global scale. By 2050, it is predicted that 6 billion people – by then about 70% of the world's population - will reside in urban areas (UNITED NATIONS, 2008). Cities as a habitat play an important role in human life but are often prone to natural hazards: the recent Haiti earthquake has just illustrated the disastrous consequences of an earthquake striking a densely populated area (www.zki.dlr.de).

In the immediate aftermath of a major disaster, the priorities are undoubtedly medical and rescue needs (Coburn & Spence, 1992). The effectiveness of emergency planning strongly depends on reliable information on a cities population and its dynamics. Existing techniques for population data generation do not match the requirements of today's cities. Additionally, inventory data – especially in developing countries – might be incorrect, outdated or not available at all. In this context, satellite imagery has been increasingly used as an independent and up-to-date source of information over the last years. However, the apprehensible excitement and enthusiasm by the scientific community in the advent of high to very high resolution satellite imagery such as IKONOS and Quickbird, lead to the impression of very high resolution images being the solution to all data generation problems. A rational discourse on the suitability of satellite images as a source of information for urban applications is still missing. The study presented in this paper aims at constituting the first step towards a quantitative evaluation of the suitability of high resolution

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satellite imagery (IKONOS) for urban population modelling. Based on a statistical comparison between population distribution modelled using satellite images and population distribution modelled using GIS and secondary sources, the limitations and advantages of IKONOS imagery for population modelling are discussed. As a test site for this case study the district of Zeytinburnu in Istanbul (Turkey) has been selected.

Theory and Method

In the past, censuses, surveys, and official registration systems served as the main source for accessing information on population. In many cases, traditionally applied techniques are too time- and cost-intensive to cope with today's population dynamics and with the increasing spatial extent of urban areas. In addition, census data are usually conducted on a decennial basis and afflicted with the problem of the so called "10-year gap". Existing population data are often only available on aggregated level and not suitable for developing emergency plans (Hardin, Jackson, & Shumway, 2007; Harvey, 2002; Newell, 1988).

To overcome problems like missing up-to-dateness and unsuitable spatial resolution, the importance of remote sensing for information extraction in urban areas is increasing. A number of previous studies attempt to investigate the capabilities of high resolution satellite imagery for population estimation. For example, Souza, Pereira, & Kurkdjian (2003) analyzed the potential of IKONOS images for estimating population for Sao Jose dos Campus (Brazil) using GIS technologies. Liu, Clarke, & Herold (2006) explored the possible correlation between the population density and textures in IKONOS images for a study site in Santa Barbara County. Further studies using IKONOS images for urban information extraction were conducted by Taubenböck, Roth, & Dech (2007) and Taubenböck, Wurm, Setiadi, Gebert, Roth, Strunz, Birkmann, & Dech (2009). In these studies IKONOS images were used as the basis for classifying patterns of urban morphology and inferring socioeconomic parameters. The main intention of Taubenböck (2008) was to analyse the capabilities of remote sensing to assess earthquake risk and vulnerability in the megacity Istanbul. The vulnerability assessment was conducted for the district of Zeytinburnu (Istanbul) including the development of the building inventory categories which are based on physical parameters such as building density and height. These parameters were then used to estimate the population density and to model its spatial distribution. In the following section, the population estimation methodologies are explained in detail as the results of Taubenböck (2007) and Taubenböck (2008) are used for the statistical comparison in this study.

For the population estimation, two approaches using different external data sources were developed. The first approach included a top-down methodology. First, a combination of physical city characteristics such as land use and building density was used to delineate 24 physically homogeneous structural zones. In order to calculate the residential living space for each zone, the residential built-up area extracted from IKONOS image was multiplied by the number of floors calculated from the remotely estimated building height. Using the district population, the average number of inhabitants for each zone was calculated. Employing other land use categories such as commercial areas extracted from IKONOS image, the residential day and night-time population was calculated. The second approach uses a bottom-up methodology based on information about the inhabitants of 50 sample buildings obtained in a field survey conducted by Taubenböck (2007). Using this information, for each urban zone an average number of inhabitants per building was calculated. In combination with the estimated residential area in a zone, the number of inhabitants per square meter was calculated (Taubenböck, 2007).

The methodologies for population estimation presented by Taubenböck (2007) involve the development of several intermediate data sets which serve as an input for the following methodological steps. As the overall uncertainty and accuracy of the population estimates strongly depends on the level of accuracy of the input data, all intermediate results are quantitatively compared to the results from the GIS-based approach presented in this paper.

Development of an up-to-date single building inventory for Zeytinburnu

The population estimation by Taubenböck (2007) involves the extraction of residential areas in Zeytinburnu. In order to be able to analyse the accuracy of this base data set, an up-to-date single building inventory for

Zeytinburnu is developed. A digital building outline data set developed in the *Zeytinburnu Pilot Project* forms the basis in this first part. This data set is primarily complemented using building outlines from the *Earthquake Master Plan for Istanbul*. It is important to note that the building inventory from these two studies showed significant deviations. To eliminate the ambiguities and to ensure the developed inventory data set only includes presently existing buildings, the two above mentioned data sets are compared and complemented by other data sets. Digital administrative boundaries for the district of Zeytinburnu and for the city of Istanbul are available from the study *A Disaster Prevention/Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey*. For the comparison, the data from Taubenböck (2007) are clipped to the same administrative boundary as used in this study.

Spatial assessment of occupancy categories in Zeytinburnu

Based on the up-to-date single building inventory, the second step includes the assessment of the spatial distribution of different occupancy categories for every single building in Zeytinburnu. The main data sources are the *Zeytinburnu Pilot Project* and the *Earthquake Masterplan for Istanbul*. The resulting data set displays the spatial distribution of different building occupancy categories in Zeytinburnu. Using the building inventory developed with data of Taubenböck (2007), a data set including the occupancy categories of Zeytinburnu was developed. For a better comparison of the two data sets generated in this section, the occupancy categories are limited to the following categories: (1) commercial, (2) residential-mixed, and (3) rest (see figure 1 and 2).

Night-time population distribution modelling for Zeytinburnu

Besides building occupancy, the number of floors is an essential parameter for population modelling. Therefore, the floor numbers included in the *Zeytinburnu Pilot Project* are assigned to the GIS-based building inventory. For the data set provided by Taubenböck (2007) only categorical floor number information is available. In this study, the night-time population modelling is based on the generalizing assumption that most people reside at home at night-time. In a first step, combining residential occupancy and usable space gives the available residential living space.

Figure 1: Distribution of simplified occupancy categories in Zeytinburnu on single building level based on Kubanek (2010)

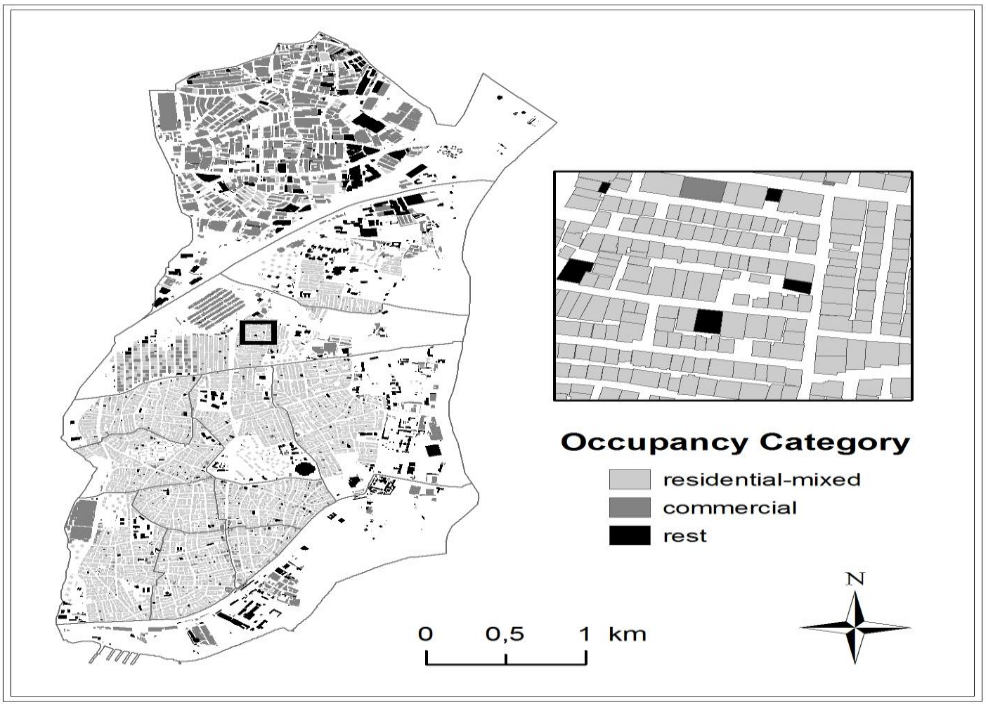
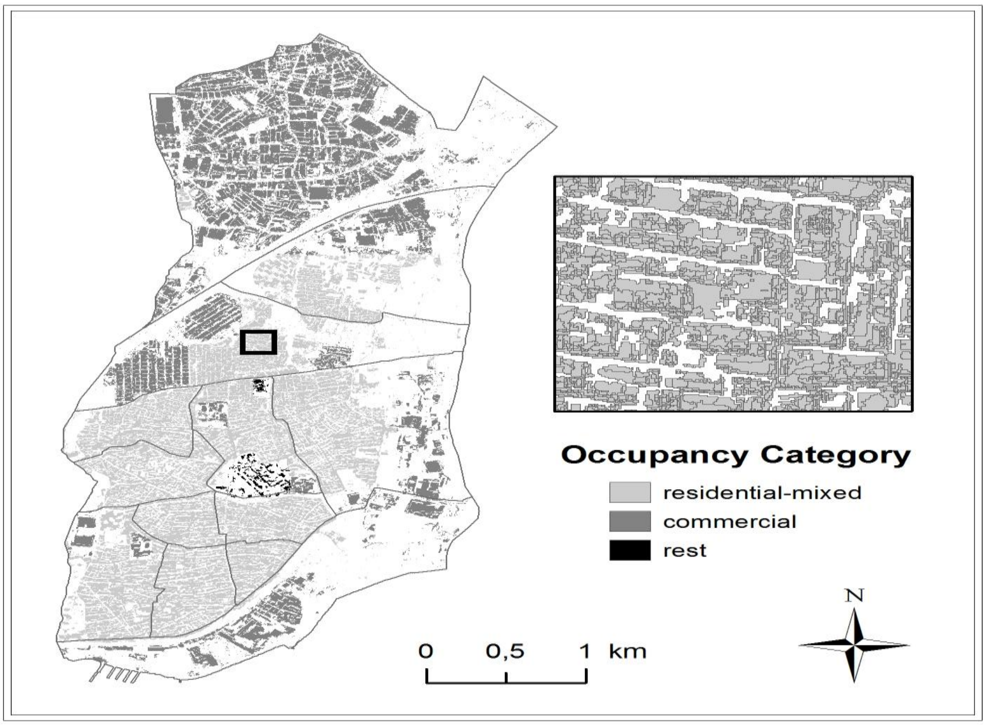


Figure 2: Distribution of simplified occupancy categories in Zeytinburnu based on Taubenböck (2008)



In a second step using a top-down approach, the average residential living space (m²) per person is estimated for each Mahalle (sub-district) by dividing the total residential living space by the total Mahalle population provided by the *2000 Census*. To estimate how many people live in a single building, the living space of every single residential building was divided by the averaged living space per person. The same methodology was applied to the data from Taubenböck (2007) in order to ensure the comparability between the GIS-based and the remote sensing based data set.

Cost analysis

Population data collection is a very time- and cost-intensive task. Taubenböck (2009) emphasised that the cost and effort can be significantly reduced if remote sensing technique is integrated in the data collection scheme. However, the costs associated with employing cutting-edge technology are still considerably high. In addition, census data generally need to be purchased from census bureau or other official authorities and are only freely available on aggregated level. For the methodology introduced in this paper, the following costs need to be considered:

(1) Satellite imagery
For the presented analysis, a high-resolution satellite imagery (IKONOS) was used. One km² of IKONOS imagery with the accuracy required costs US$33. The total area of the Zeytiburnu district is 11.5 km². In order to implement the presented techniques for the whole of Istanbul with an area of 1830 km², the corresponding image would cost approx. US$45540 (E-geos, 2009).

(2) Software license
The license fees for software packages used have also to be taken into account. The market leader for object-oriented image analysis software Definiens used by Taubenböck (2007) charges approx. US$8000 for their software package Definiens Developer. For data analysis Arctic 9.3 was used in

this study. ESRI charges US$3325 for a multi-user educational license and US$670 for a basic single user license plus US$400 for extensions such as spatial analyst.

(3) Data/ Data acquisition
The data used in this study were freely available on the courtesy of the project partners. In general data acquisition costs can be substantial. As mentioned in the introduction, sample surveys are very expensive tasks due to the high number of people involved. As validation data such as census data might be not available - especially in many developing countries, the validation relies on data from time- and cost-consuming surveys.

Particularly less developed countries or NGOs might not be able to afford the costs associated with the presented methodology. To expand the usage of remote sensing technology for population modelling and data generation in general, the use of open source software needs to be encouraged. In addition, the distribution of freely available high resolution satellite imagery needs to be extended. For example, initiatives such as the International Charter: Space and Major Disasters could provide data also in the pre-event phase to foster the generation of reliable data set – not exclusively but also for disaster management measures.

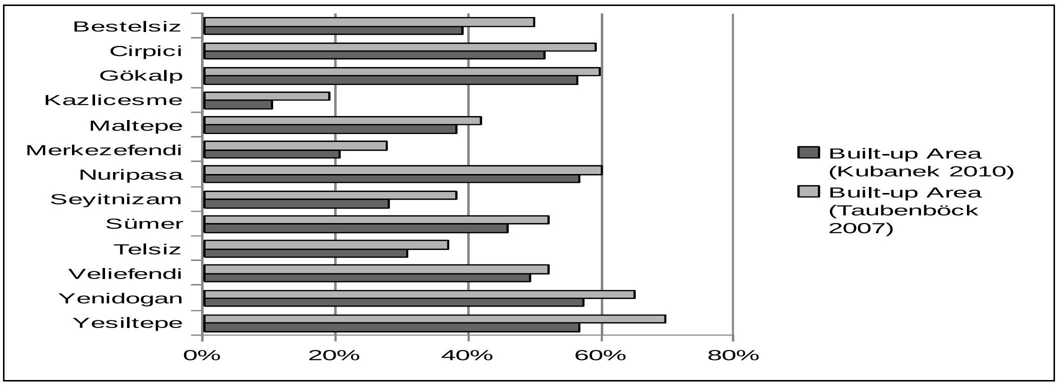
Projects like the Global Earthquake Model (GEM) make significant headway in this direction. GEM aims at providing the first global, open source model for seismic risk assessment at a national and regional scale. This model also includes a model for data generation incorporating the use of satellite imagery and open source GIS software. The authors of this present paper and other researchers associated with the Center for Disaster Management and Risk Reduction Technology (www.cedim.de) at the Karlsruhe Institute of Technology (www.kit.edu) and the German Aerospace Center (www.dlr.de/en) are involved in the data generation work within GEM.
Global applicability

Global applicability of data generation techniques depends on the global availability of the required input data. For the presented approach for population modelling, the following five data sets are essential: (1) up-to-date single building inventory, (2) administrative boundaries of sub-districts or unit of analysis, (3) occupancy of single buildings, (4) height information of single buildings, and (5) population data aggregated on sub-district level.

Results

The presented comparison proves that high resolution satellite images can be successfully employed for urban parameter extraction. However, some constraints were identified in this study. Figure 3 shows the results for extracted built-up area from IKONOS by Taubenböck (2007) and the built-up area calculated in this study. From figure 3 it becomes obvious that Taubenböck (2007) overestimated the built-up area of each

Figure 3: Comparison of built-up area in % generated by Kubanek (2010) using a GIS software and based on Taubenböck (2008) extracted from IKONOS imagery



Mahalle by approximately 10% compared to the GIS-based inventory. The comparison of the simplified occupancy categories revealed the same deviation. As buildings like other objects are identified from satellite images through their reflective signature, the observed deviations are mainly caused by similar spectral characteristics of land cover categories like built-up area and its surroundings such as streets or bare ground. The similarity strongly depends on the roofing material of the buildings. For example, concrete building with tiled roofs are easier to distinguish from tarmac than concrete roof with the same greyish colour. In the second step of this study, simplified occupancy categories on Mahalle level were compared. Taubenböck (2007) subdivided the buildings into four classes: residential-mixed, commercial, military and hospital; in this study (in the following referred to as Kubanek (2010)) the following classes were used: industrial, commercial, residential, other, mixed, depot, service, under construction, vacant, and unknown. Due to the very broad categorization scheme applied by Taubenböck (2007), almost no buildings are assigned to a "rest" category (see figure 1 & 2). This comparison demonstrated the capabilities of high resolution satellite imagery to delineate occupancy categories. The determined percentage of occupancy types shows the same trend for some Mahalles. For example, Kubanek (2010) identified a large share of residential living space for some Mahalles (figure 1 & 2); the occupancy data generated by Taubenböck (2007) display the same trend. The same can be observed for Mahalles with little residential living space.

Figure 4: Distribution of night-time population in Zeytinburnu on single building level based on Kubanek (2010)

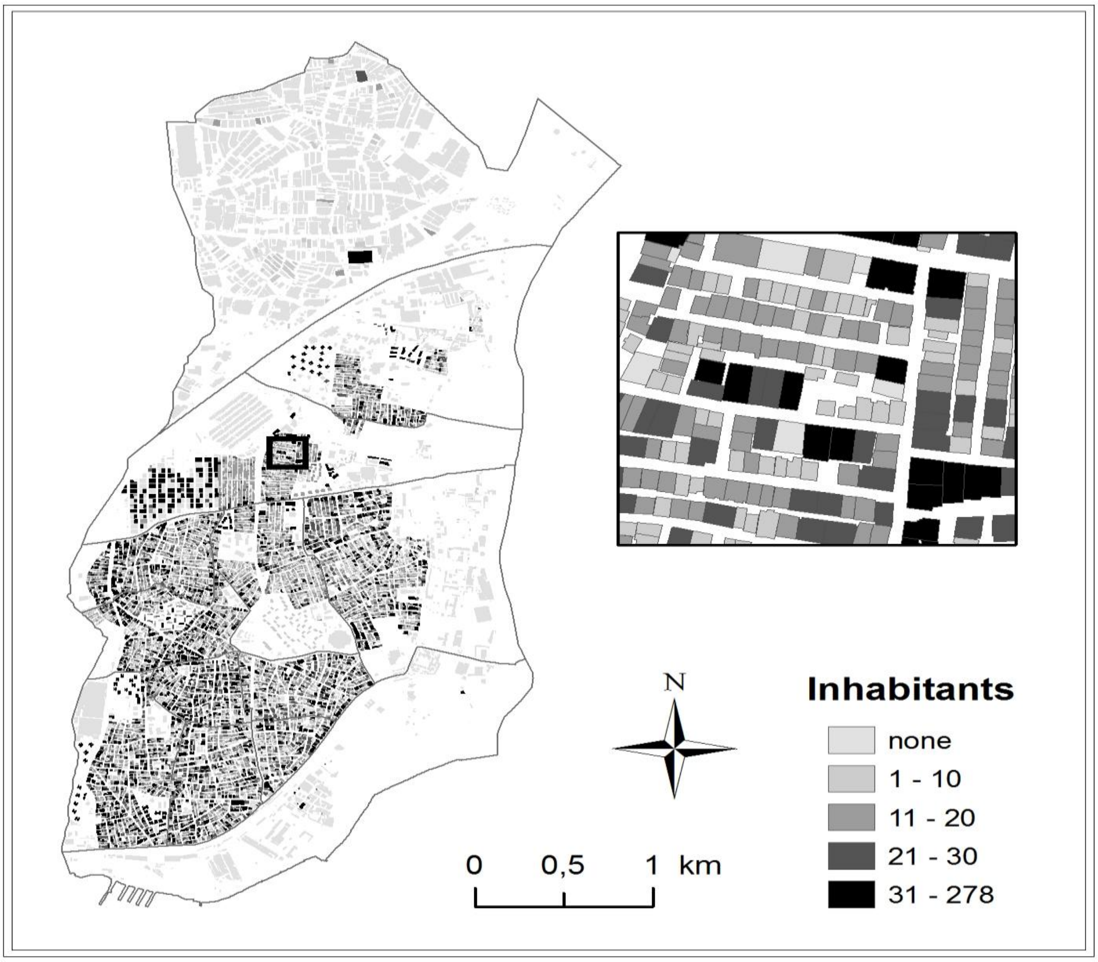
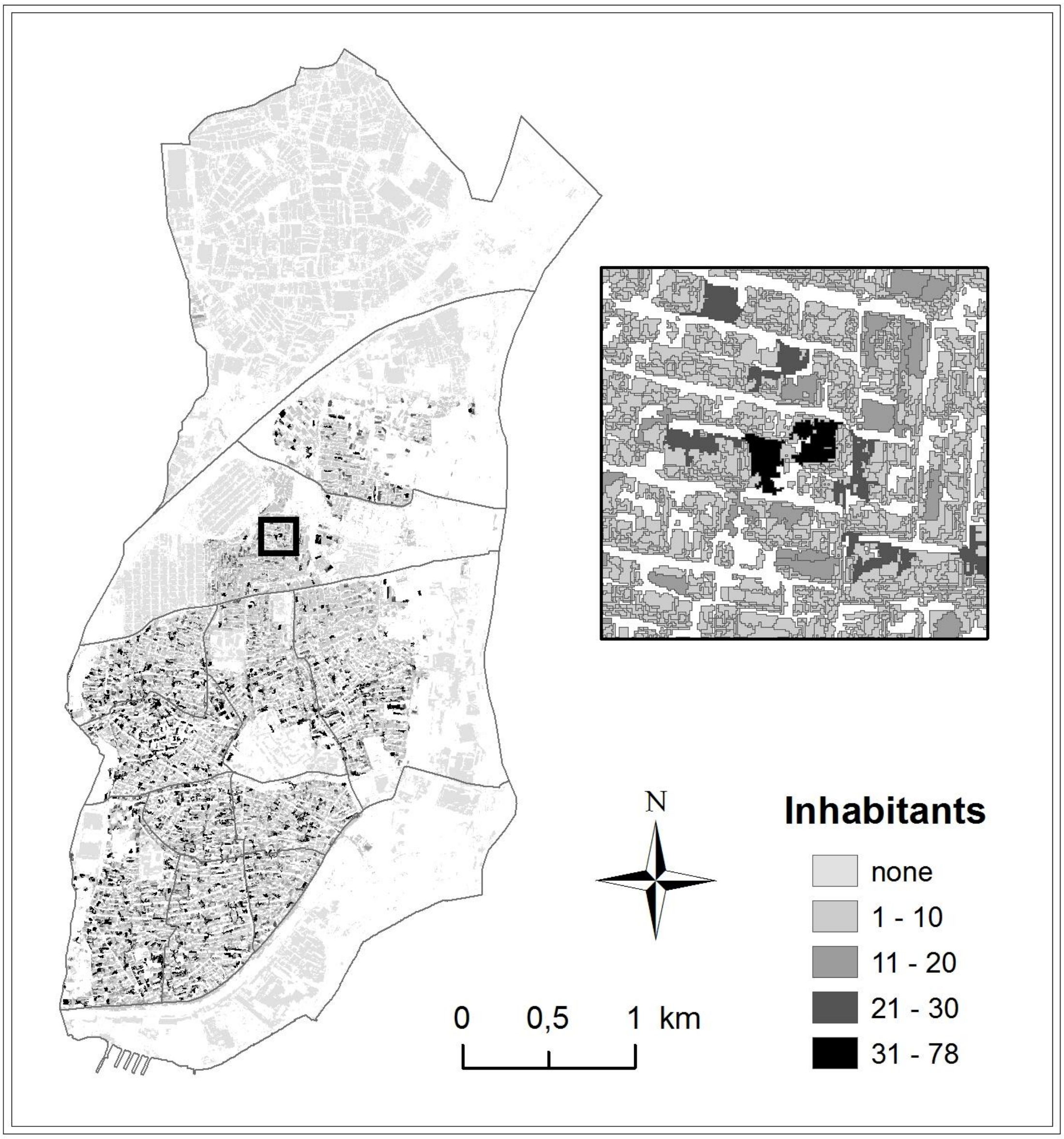


Figure 5: Distribution of night-time population in Zeytinburnu based on Taubenböck (2008)



The comparison of the population distribution in Zeytinburnu constitutes the last step of this analysis. Figure 4 shows the GIS-based population distribution in Zeytinburnu modelled using data from Kubanek (2010), figure 5 shows population distribution based on data from Taubenböck (2007). In general, the number of inhabitants per building is higher in the southwestern part of Zeytinburnu, in the so called "residential districts". A significant lower night-time population is modelled for the industrial districts in the northern part of Zeytinburnu. For a more detailed comparison, a small section of Zeytinburnu from both data sets is displayed in figures 4 and 5. It becomes obvious that the population modelling by Kubanek (2010) is based on realistic single building footprints whereas the built-up area extracted from IKONOS by Taubenböck (2007) does not depict single buildings. This is the main limitation for utilising very high resolution optical imagery for per-building population modelling as the extraction of single buildings proofed to be very difficult for urban areas.

Discussion

Figure 6: Residential living space per Mahalle in square kilometer. Comparison between Taubenböck (2008) and Kubanek (2010)

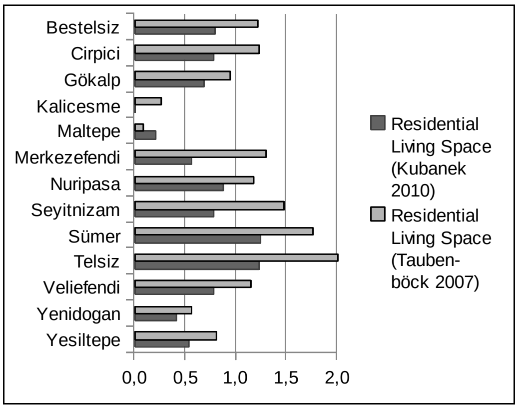
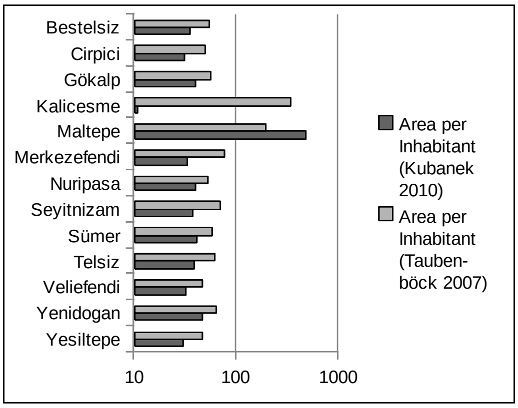


Figure 7: Area per inhabitant on Mahalle level in square meter. Comparison between Taubenböck (2008) and Kubanek (2010)



This study focused on the quantitative assessment of the capabilities and limitations of optical high resolution satellite imagery for population modelling in urban areas. The findings confirm that these kind of images are a valuable source of information for modelling population distribution on sub-district level. However, the overestimation of the built-up area due to the limitations of optical images (figure 3) constitutes a major source of error as it results in a constant overestimation of the residential area per Mahalle and consequently in an overestimation of the averaged residential living space per person on Mahalle level (figure 6). Considering an average overestimation of 10%, the question arises whether this methodology is suitable to provide information for risk managers and urban planners. From the present study, we conclude that modelling population distribution on building level is feasible using automatically extracted building footprints only with a certain loss of accuracy. Satellite images prove to be a valuable source to supplement existing building inventory data.

Another source of error is the estimation of the floor numbers from high resolution optical satellite images. As the floor number is estimated from building height which is derived from building shadows, the floor numbers can only be provided as categorical data. Inaccuracy also arises from the use of mixed occupancy categories. Buildings with different occupancies on different floors were classified as mixed. In order to calculate the residential living space in a building, the footprint area should be multiplied with the number of residential floors only and not with the total number of floors. As this presented study is ongoing research, the next step will include an analysis of the buildings to obtain a more precise distribution of the residential floors and thus of the population. A further methodological step may include the consideration of employment and commuting population to model the daytime population. Different approaches on the estimation of building height using remotely sensed data sets have already been completed. Using LaserScan data in combination with IKONOS data showed a significant increase in the building height and floor estimation (Wurm, Taubenböck, Roth, & Dech, 2009).

From an emergency planning perspective, the overestimation in all steps of the analysis is of minor importance as only with underestimation might have severe consequences in case of a disaster. Although population estimates per building level using remote sensing might be not sufficiently accurate for the coordination of rescue teams and fire brigade, the generated population data can provide a valuable insight to the distribution of potentially affected people on district level in case of a disaster.

Although the study site was selected because of the high earthquake hazard, the presented methodology is not limited to densely populated areas and earthquake risk. The knowledge of the spatial distribution of the inhabitants of an entire city including scarcely populated outskirts also plays a critical role for risk reduction and mitigation strategies for other hazards such as tsunamis, floods, or volcanic eruptions. Another important issue related to population modelling is the identification of crowded places and the assessment of the potential for human crowding. This information is for example essential for determining places at risk from terrorist attacks. In addition, the health sector is interested in building level population data, for example for pandemic prevention or for identifying people at risk concerning the contamination e.g. of drinking water.

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危险材料事故中的受伤人数量化研究

Nils Rosmuller, Inge Trijssenaar

【摘要】在荷兰的量化风险分析领域，已经对因涉及危险材料意外死亡的概率进行了计算。计算结果主要用于用地规划。在荷兰，消防队在给政府提供关于接受或否决对危险材料及活动进行处理的网络和交通路线建议方面发挥着重要作用。然而，应急响应必须处理伤亡人员，更关心伤亡人员的数量和伤亡类型等信息。我们开发了一种计算伤亡人数的方法。这个方法已经在荷兰最大的火车站、有大量客流和危险材料运输的乌德勒支中央车站使用。消防队使用计算出来的伤亡信息对空间规划和核生化交通规划进行审批，决定这些活动的抑制策略和必要的设备需求。

【关键词】受伤；量化；危险材料；火车站；质量可靠性保证

QUANTIFICATION OF THE NUMBER OF INJURED PEOPLE DUE TO HAZARDOUS MATERIAL ACCIDENTS

Nils Rosmuller[9], Inge Trijssenaar

Keywords

injuries, quantification, hazardous materials, railway station, QRA

Abstract

In the Netherlands, in quantitative risk analysis (QRA), the probability on fatalities due to accidents involving hazardous materials is calculated. The results are mainly used for land use planning. In the Netherlands, fire brigades play a major role in advising the governors in accepting/rejecting activities regarding hazardous materials or activities near sites and transportation routes where hazardous materials are processed. However, instead of fatalities, emergency responders have to deal with injured persons, and therefore they much more appreciate information concerning the number of injured people and their types of injuries. We developed a method for calculating the number of injured people. This method was applied to the largest railway station in the Netherlands, Utrecht Central station where in addition to passengers also substantial amounts of hazardous materials are transported. The fire brigades used the injury information for (dis)approving the spatial plans and hazmat transportation plans, determining their suppression tactics and necessary equipment.

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1. Introduction

In the Netherlands, in quantitative risk analysis (QRA), the probability on fatalities due to accidents involving hazardous materials calculated. The safety op people near stationary installations and transport infrastructures is analyzed using quantitative risk analyses (QRA). In state of the art QRA's, risk is expressed in the chance a person gets killed because of an accident or a group of persons gets killed at the same time. However, additional insights in safety are needed, such as the number of injured (persons who need medical treatment) and their type of injuries. Emergency response organizations such as the fire brigades and medical aid might use these kinds of insights to prepare for disaster abatement and shape their own organizations regarding capacity and skills.

In section 2 we present a way how to calculate the number of injuries due to hazardous materials accidents. In section 3 we apply these calculation rules to a real life situation in the Netherlands, namely Utrecht central railway station. In section 4, we draw conclusion regarding the developed rules and its application.

2. Research approach

2.1 Injury modeling for toxic chemicals

Based upon the work of Purser [2007], Trijssenaar [2007 and 2009] published about the way the number of injured victims can be calculated. For toxic injuries a distinction is made between chemicals that have a dose related threshold for sub lethal injuries and chemicals that have a concentration related threshold. This subdivision stems from the Fractional Incapacitating Dose (FID) and Fractional Irritant Concentration (FIC) models developed for toxic fire products by Purser (Purser 2002, Trijssenaar 2007). The general equation for the FID and FIC methods are:

$$FID = \sum_{i=1}^{n}\sum_{t=0}^{t}\frac{C_i}{(D_{threshold})_i}\Delta t = \sum_{i=1}^{n}\frac{D_i(t)}{(D_{threshold})_i} \quad (1)$$

$$FIC = \sum_{i=1}^{n}\frac{C_i}{C_{threshold}} \quad (2)$$

Where:

C_i = average concentration in ppm of chemical "i" over the chosen time increment;

Δt = chosen time increment in min;

$D_i(t)$ = dose of chemical i at time t;

$(D_{threshold})I$ = the threshold dose in ppm*min;

$C_{threshold}$ = threshold concentration for chemical "i" in ppm.

Because the *FID* and *FIC* threshold values are only known for fire products, other threshold values are required for toxic chemicals. The Acute Exposure Guideline Level 2 (AEGL-2) is very suitable for the definition of ability of self-rescue. AEGL-2 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or *any impaired ability to escape* (EPA 2009). AEGL-2 values are available for exposure durations of 10 minutes, 30 minutes and 1 hour, 4 hours and 8 hours. The subdivision of several chemicals in asphyxiant and irritant as well as their threshold values are shown in

Table 1. The chemicals in Table 1 are representative for various hazard categories as used in QRA's.

Table 1: Subdivision and AEGL-2 threshold values of toxic substances.

substances	Subdivision	Concentration (ppm)	
		10 min exposure	30 min exposure
Acrylonitrile	FID	290	210
Ammonia	FIC	220	220
Chlorine	FIC	2.8	2.8
Methylisocyanate	FID	0.40	0.13
Nitric acid	FIC	43	30

* IDLH threshold value.

The *FID* and *FIC* relations are slightly adjusted for the use for toxic chemicals, where generally only one chemical at a time is released and often more detailed knowledge of the time dependence is present.

$$FID = \int_0^t \frac{C^n(t)}{C^n_{AEGL2\_30\min}} dt \qquad (3)$$

$$FIC = \frac{C}{C_{AEGL2}} \qquad (4)$$

Where:

C = chemical concentration in ppm ;

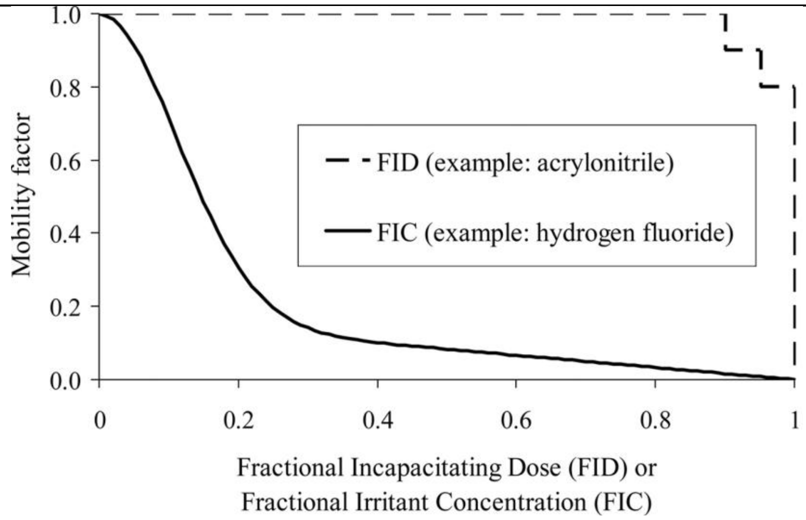
n = dimensionless constant, derived from AEGL-2 values of the chemical or from the probit relation for lethal injuries (purple book 1999).

C_{AEGL2_30min} = the AEGL-2 value for 30 minutes exposure time in ppm.

C_{AEGL2_30min} = the AEGL-2 value in ppm of an irritant chemical is generally equal for 10 minutes and 30 minutes exposure time, if there is a slight difference then -conservatively – the 30 minutes AEGL-2 value is assumed.

Chemicals with dose related sub lethal injury are assumed to show a similar relation of *FID* to mobility as asphyxiant fire products. For these asphyxiant fire products, the time to incapacitation and its severity usually show a short period of intoxication that is followed by a relatively sharp decline into incapacitation. The relation between *FID* or *FIC* and mobility is shown in Figure 1 (Purser 2007).

Figure 1: FID an FIC affecting person's mobility



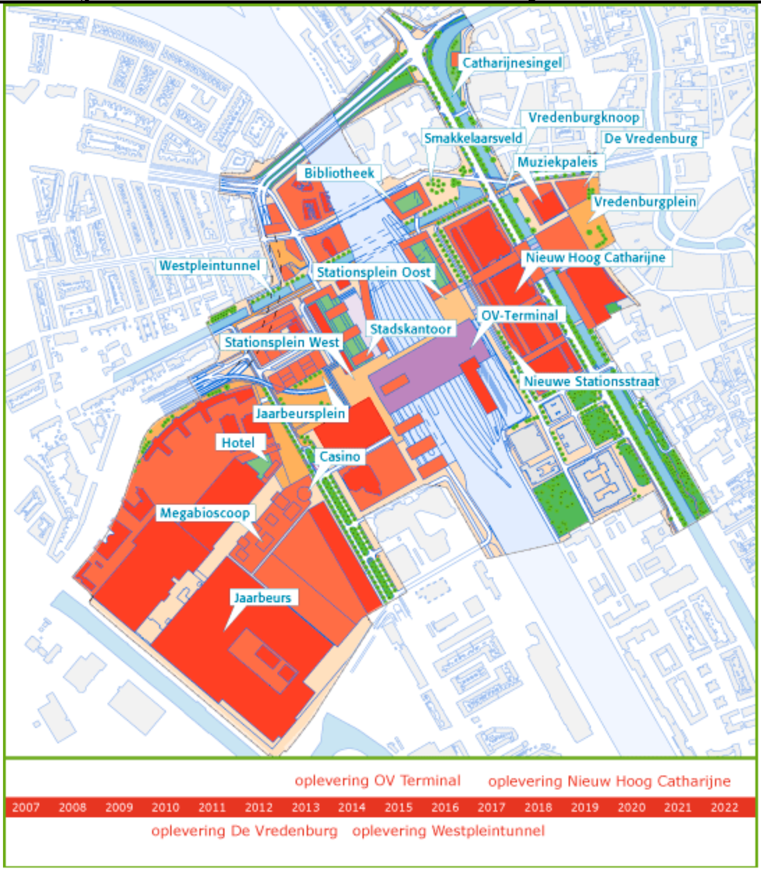
For chemicals with concentration related sub lethal injury (irritant chemicals) incapacitation occurs when the *FIC* equals unity, i.e. when the concentration equals the AEGL-2 concentration. The mobility decreases already at lower concentrations (see Figure 1) due to irritation of nose, throat, lungs and eyes. The walking velocity is calculated dynamically: when a person moves to another (safer) location, he is exposed to a lower concentration. Therefore the toxic dose will increase less compared to staying on the same location. For each time increment _t, the *FID* or *FIC* and mobility factor are calculated and used as input for the next time increment until a person either reaches a safe location or is incapable of self-rescue. A safe location is defined as a location where the concentration below the AEGL2 value of 30 minutes exposure. The safe location can be either outside, further away from the hazard source, or inside (in a building or shelter).

3. Utrecht Central Railway Station

3.1 Transport Terminal Utrecht

Terminal Utrecht handles about 13 million passengers in 2020 during a year. The terminal is a multi level building over 16 rail platforms. Adjacent to the Terminal, many buildings will be developed such as offices, a library, parking lots for cars and bicycles, hotel, cinema, shops, casino, theatre, … Figure 3 presents the railway station and the foreseen developments of buildings near the station.

Figure 2: Project in Utrecht Central station area [Gemeente Utrecht, 2007]



3.2 Hazardous material transportation

It is in this intensively used area are hazardous materials by railcar are transported. The following numbers of categories of hazardous materials are transported via Utrecht Central station in the future (ProRail, 2007).

Table 2: Hazardous material transportation

Category	Representative hazardous material	FID or FIC	Volume rail tanker (ton)	Number of rail tankers per year (in the year 2020)
Flammable liquid	n-hexane	-	Irrelevant for calculation	1200
Toxic liquid	Acrylonitrile	FID	Irrelevant for calculation	300
Flammable gas	Propane	-	48	600
Toxic gas	chlorine, ammonia	FID	50	4700

As for these substances, we specified the injury criteria for flammables and toxics.

- **Flammables:**

Damage to buildings:

- Heat radiation 35kW/m2: spontaneous ignition of materials
- Heat radiation 15kW/m2: ignition of flammable materials in case an ignition source is nearby

Injuries:

- Heat radiation 35kW/m2:fatal
- Heat radiation smaller than 35kW/m2: injuries are based upon the exposure time. The % lethal injuries in the range from 90%, 50%, 10% en 1%, to 1% burning injuries.

In quantitative risk analyses, many scenarios are calculated. Scenarios depend upon the wind speed, atmospheric circumstances (stable, instable, .), the release type (continuous/instantaneous), type and extend of physical phenomena (torch, pool fire, BLEVE, ..),. In table 2, for illustrative purposes, for flammable fluids, the distances for certain heat radiation levels are depicted for 2 pool fire sizes and 2 wind speeds.

Table 3: Heat radiation levels due to pool fires (based upon EFFECTS calculation)

	n-hexane - 300 m2		n-hexane - 600 m^2	
Wind speed	*5 m/s*	*1,5 m/s*	*5 m/s*	*1,5 m/s*
35 kW/m^2	16,8 m	12 m	23,9 m	17,6 m
15 kW/m^2	31 m	25,3 m	42,2 m	35,2 m
5 kW/m^2	45 m	44,6 m	61 m	60,3 m
3 kW/m^2	52,9 m	54,8 m	71,8 m	74,1 m
1 kW/m^2	76,8 m	84,6 m	104,8 m	114,5 m

- **Toxics:**

Two thresholds criteria will be used:

- Alarm threshold (AGW): the concentration of a substance above irreversible injuries will occur in case of a 1 hour exposure
- Live threatening threshold (LBW): the concentration of a substance above lethal injuries will occur in case of a 1 hour exposure

Table 4: thresholds criteria

	Threshold (mg/m^3)		
Criterion	**Chlorine**	**Ammonia**	**Acrylonitrile**
AGW	10	100	50
LBW	50	500	200

Like for flammable fluids, many scenarios are possible for toxic substances. Scenarios depend upon the wind speed, atmospheric circumstances (stable, instable, .), the release type (continuous/instantaneous), type and extend of physical phenomena (evaporation speed, release period..). In table X, for illustrative purposes, for toxic fluids, the distances for reaching the AGW and LBW levels are depicted for 2 pool sizes and 2 weather class (wind speeds/atmosphere) combinations (D5= neutral and wind speed is 5m/s (ordinary day-circumstances in the Netherlands); F1,5 is very stable and wind speed 1,5 m/s (ordinary night-circumstances in the Netherlands)).

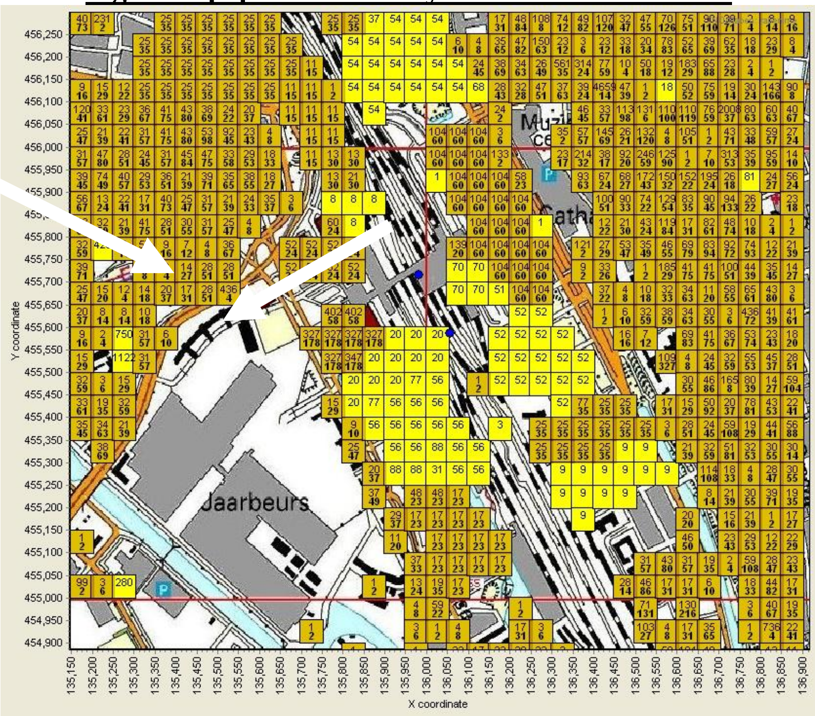
Table 5: Toxic scenarios and AGW and LBW distances.

In urban environment	**Toxic pool size**							
	Acrylonitrile – 300 m2				**Acrylonitrile – 600 m2**			
Weather class	*D5*	*F1,5*	*D5*	*F1,5*	*D5*	*F1,5*	*D5*	*F1,5*
Evaporation speed (kg/s)	0,64	0,25	0,64	0,25	1,23	0,48	1,23	0,48
Time after release	*Distance to AGW*		*Distance to LBW*		*Distance to AGW*		*Distance to LBW*	
2 minutes	375	217	151	198	522	224	231	208
5 minutes	375	501	151	429	568	523	231	469
10 minutes	375	907	150	564	574	973	233	789
15 minutes	373	1231	150	564	572	1373	232	890

Tables like table 3 and 5 have been developed for other substances and scenarios as well.

Next we have to imagine a place where the accident occurs and assess the number of people within the calculated consequences distances in these tables. We located the release (accident) on the most probably part of the Utrecht CS marshalling yard, namely at switches in the preferred and hazardous material rail tracks. Figure 3 present the accident spots (blue dots and indicated by the white arrows) and the number of person apparent in the grid cells near Utrecht CS. The numbers in the cells present the day and night time (bold) number of people apparent at that location. We used the Utrecht municipality database for obtaining these numbers.

Figure 3: population density and accident locations.



Fatalities

We calculated the number of fatalities for two typical Dutch weather class situations and specified these numbers per substance per physical phenomenon.

Table 6: Number of lethal victims weather classes D5 en F1.5 for flammable and toxic substances

Substance	Scenario	# fatalities D5	# fatalities F1.5
Propane	Warm BLEVE	735	735
	Cold BLEVE	80	80
	Torch	0	0
	Vapor cloud explosion	3300	395
n-Hexane	Instantaneous	0	0
	Continuous	0	0
Ammonia	Instantaneous	35	40
	Continuous	5	40
Chlorine	Instantaneous	1 745	1 435
	Continuous	975	2 440
Acrylonitrile	Instantaneous	0	5
	Continues	0	2

Injuries

To calculate the number of injuries, to prevent for double counting, we subtracted the number of fatalities from the number of people apparent in the environment.

Table 7: Number of injuries flammable scenarios weather class D5

Substance	Effect/ Scenario	# fatalities	# injured-total	# 3e degree injuries	# 2e degree injuries	# 1e degree injuries
Propane	Warm BLEVE	735	90	0	40	50
	Cold BLEVE	80	160	0	50	110
	Torch	0	0	0	0	0
	Vapor cloud explosion	3300	0	0	0	0
n-Hexane	Instantaneous	0	0	0	0	0
	Continuous	0	0	0	0	0

Table 8: Number of injuries flammable scenarios weather class F1,5

Substance	Effect/ Scenario	# fatalities	# injured-total	# 3e degree injuries	# 2e degree injuries	# 1e degree injuries
Propane	Warm BLEVE	735	90	0	40	50
	Cold BLEVE	80	160	0	50	110
	Torch	0	0	0	0	0
	Vapor cloud explosion	395	0	0	0	0
n-Hexane	Instantaneous	0	0	0	0	0
	Continues	0	0	0	0	0

Because of the brand new character of the injury calculation method, we compared our calculation results to already existing calculations methods. We applied the existing methods o the same area Utrecht CS. We used three other calculation methods, including the method as being used by medical aid teams (GHOR-method), a rule of thumb method (Leidraad Maatramp) and the Green book.

Table 9: Number of inured persons due to toxic scenarios; weather class D5.

Substance	Scenario	TNO Method	GHOR	Leidraad maatramp	Green book
Ammonia	Instantaneous	1704	139	560	8561
	Continues	144	12	80	72
Chlorine	Instantaneous	> 25000	24510	27920	> 25000
	Continues	> 25000	>25000	15600	> 25000
Acrilnitrile	Instantaneous	23	21	0 tot 40	33
	Continues	21	12	0 tot 40	19

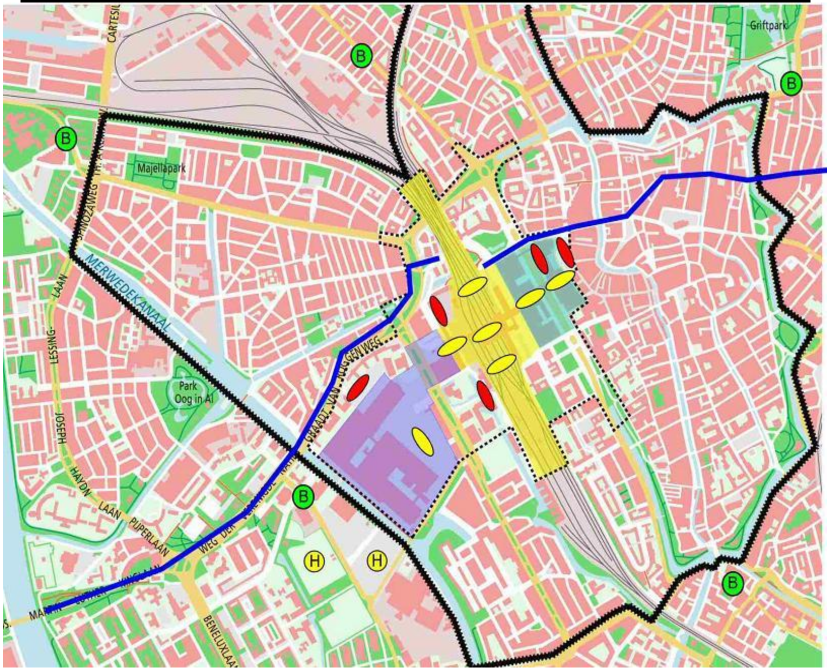
Table 10: Number of inured persons due to toxic scenarios; weather class F1.5.

Substance	Scenario	TNO Method	GHOR	Leidraad maatramp	Green book
Ammonia	Instantaneous	1750	249	640	916
	Continues	1450	1	640	109
Chlorine	Instantaneous	> 25000	22036	22960	> 25000
	Continues	> 25000	25000	39040	> 25000
Acrilnitrile	Instantaneous	671	209	80	328
	Continues	187	76	32	109

4. Emergency response usage of injury information

The injury quantification was the input for the emergency responders to make their preparations for disaster abatement. For the emergency responders, the exact accident location is less relevant. For them, the accessibility of the disaster area is relevant and the locations where they can park their vehicles and develop their emergency response centre (communication, mobile hospitals, decontamination units,…). Figure 4 presents an overview of the railway station area and the parking locations for fire engines (red ellipse), the ambulances (yellow ellipse), and the locations for large scale gathering of fire engines (green circle B) and medical vehicles (yellow circle H). The large scale locations are outside the restricted area in times of disasters (the bold black line in figure 4).

Figure 4: Emergency response location in Railway station area.



In addition, for each of the assessed scenarios the emergency responders developed a time line and the minimum emergency response capacity. For example for the continuous release of a toxic gas (ammonia) the emergency response time line is presented below.

Phase	Action	Capacity
1	ammonia release, toxic dispersion into environment	40 fatalities and 1450 injuries
2	Emergency responders assess disaster area	1st fire engine within 8 minutes 1st ambulance within 15 minutes
3	Locating vehicles	A few vehicles in disaster area, large scale help (many fire engines) on locations outside area
4	Marking disaster area and alarming the direct environment	Marking is a police activity. The major is responsible for alarming the citizens
5	Fire fighters in chemical suits assess the accident. Eventually closing the leaking gap or otherwise rarefy the toxic cloud. In addition scope and run of injured victims	Calling in the fire engines (1 or multiple fire company: 9 fire engines, command centre and support unit)
6	Follow up/after care. Picking up the fatalities and decontaminating the emergency responders.	Decontamination unit

Comparing the necessary emergency response capacity and the availably capacities, the emergency responders concluded that there is a big shortage of emergency response capacity. More specific, the number of ambulances and beds in hospitals fall short during the first few hours after the start of the incident. Several solutions exist to deal with these shortages:

- Decision makers accept the shortages
- Extending the emergency response capacity

- Taking measures in spatial planning
- Taking measures in the hazardous materials transportation flow
- Taking measures to prepare the citizens

Within these categories, more detailed measures have been elaborated in terms of their contribution to reduce the risks, their costs and the transportation and spatial planning impacts. Suggestions have been done to the local and national politicians/decision makers whom responsibility it is to decide upon. At this moment, decisions are still pending.

5. Conclusions

We presented a method to calculate the number of injuries due to hazardous materials accidents. We applied this method to Utrecht Central Railway station. The results proved to be very useful for emergency responders. They used the injury information to evaluate their emergency response capacity, to advise decision makers regarding the group risk figures and to advise the decision makers on self rescue, risk communication and disaster abatement.

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大规模人员疏散管理案例

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【摘要】在大多数情况下，自然灾害往往导致大规模人员疏散。有了辅助决策系统所提供的信息后，疏散管理的质量得到大大提升；这已经成为大范围疏散行动中不可或缺的管理工具。这篇文章介绍了一个案例。2007 年 11 月，罗马尼亚 Bihor 县的应急管理官员参加了一次跨国界疏散演习，在这次演习中，700 人从荷兰疏散到比利时。这次演习的一个主要目的是测试 4 个不同的辅助决策系统。之后，在这次演习所获得的经验的基础上，一套名为 TEVAC（跨国界疏散）的软件系统被开发出来。TEVAC 在 2008 年 9 月举行的、由 200 人从匈牙利疏散到罗马尼亚的欧盟联合演习 EU-HUROMEX 2008 中得到了成功测试。在总结经验教训和成果的基础上，从 2009 年 4 月开始，TEVAC 软件在罗马尼亚全国的应急监控机构中投入使用。

【关键词】紧急疏散；TEVAC 软件系统；用户接口设计；搜索

THE MANAGEMENT IN LARGE EMERGENCY SITUATIONS - A BEST PRACTISE CASE STUDY FOR MANAGEMENT OF EVACUATION

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Keywords

Emergency evacuation, TEVAC (Trans Border Evacuation) software system, User Interface Design, Searching Features

Abstract

In most of the cases, natural disasters lead to the necessity of evacuating people. The quality of evacuation management is dramatically improved by the use of information provided by decision support systems, which become indispensable in case of large scale evacuation operations. This paper presents a best practice case study. In November 2007, officers from the Emergency Situations Inspectorate “Crisana” of Bihor County from Romania participated to a cross-border evacuation exercise, when 700 people have been evacuated from Netherlands to Belgium. One of the main objectives of the exercise was the test of four different decision support systems. Afterwards, based on that experience, software system called TEVAC (Trans Border Evacuation) has been developed “in house” by the experts of this institution. This original software system was successfully tested in September 2008, during the deployment of the international exercise EU-HUROMEX 2008, the scenario involving real evacuation of 200 persons from Hungary to Romania. Based on the lessons learned and results, starting from April 2009, the TEVAC software is used by all Emergency Situations Inspectorates all over Romania.

Introduction

Most of the time, major emergency situations imply people evacuation from the endangered area. In fact, the intervention efficiency of professional emergency services resides in their capacity to protect lives and goods. While in case of “normal” intensity fires or floods, these services can adopt offensive tactics as fire fighting or a dike consolidation, during a disaster, the only efficient action is the evacuation of people and goods from the threatened areas.

“Emergency evacuation” (http://en.wikipedia.org/wiki/Emergency_evacuation) is a measure of civil protection taken prior, during or after an emergency situation occurs, when the alert situation is declared, which consists in removing people, animals and goods, away from the threat or actual occurrence of a hazard, in a systematic manner from potentially endangered or affected areas, to safe places which ensure survival and protection conditions.

In the case of a small scale evacuation, the operations do not involve major problems. When we are talking about hundreds of people who need shelter as they leave the disaster area, the lack of a reliable decision support system can generate victims. Yet, such a system never existed in Romania, even if its necessity has been proved once again during the major floods in recent years.

In November 2007, a work group emerged from the Emergency Situations Inspectorate ”Crişana” of Bihor county and decided to develop such a solution.

The success of this project was confirmed by the recommendation addressed in April 2009, to all the county emergency inspectorates by the General Inspectorate of Emergency Situations, to use TEVAC software (Cross border evacuation software).

The project began in the best possible way, with the participation of two officers from the inspectorate, as “Dutch evacuated persons” at the Olympic Offspring exercise that took place on the 28th of November 2007.

The exercise consisted in a real-time evacuation of more than 700 - people from Terneuzen – Nederland to Zelzate – Belgium, one of its goals being the comparative test of four evacuation process informational systems. This event has practically been the birth date of TEVAC software.

In the first half of 2008, the regular phases of the software design project have been covered, such as defining the work flow the database structure or the design of the user interfaces.

This type of software can be tested only in the conditions that resemble real situations. This condition was achieved during the EU-HUROMEX 2008 project (http://www.eu-huro mex2008.eu/?lang_select=rom), an international emergency situations exercise attended by more that 500 -people from eight countries. During this exercise, 160 - people have been evacuated from Gyula - Hungary to Chişineu de Criş – Romania.

Defining the evacuation process concept

The design phase of TEVAC software system development project began by defining the concept of evacuation process. Thus, all the stages of an evacuation have been documented according to the legal aspects and international lessons learned and best practices, starting from the moment when the evacuation order has been issued until the evacuees have been accommodated. In the general context of an unclear legislation in this domain, the Olympic Offspring exercise experience and the support of Dutch experts has played an important role in covering this part of the project.

The final step of this process was the evacuation exercise during EU-HUROMEX 2008. The evacuation concept is schematically presented in Figure 1a (the evacuee's reception center, the mobile medical point and the accommodation center) and Figure 1b.

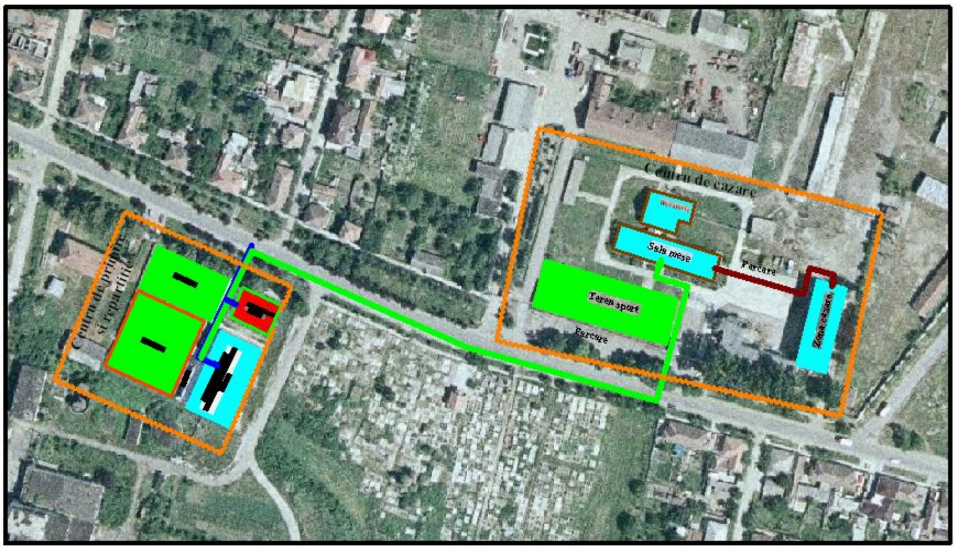

Figure 1a. The evacuation concept (the evacuee's reception center, the mobile medical point and the accommodation center)

Figure 1b. The evacuation concept

Relying on the Dutch model, the evacuees were directed the evacuees reception center - ERC which was organized in a sport hall. This solution was chosen because there are buildings of this type in many urban or even rural locations, which allow the temporary sheltering of a great number of people and the playing area can be easily organized into specific areas. At the same time, the vestibules and other annexed spaces can have specific purposes, such as: resting areas for pregnant women, a medical office or "mother and child" rooms (Figure 2).

Over time, using the sport halls as reception center for evacuees proved to be a good practice, which had been confirmed during the EU- HUROMEX 2008 exercise.

Figure 2 .The way a sport hall have been organised to cover the needs of an "evacuees reception center" - ERC

General Architecture of the system for emergency management

The general architecture of the integrated decision support system for emergency management has been detailed in (Zoicas, C., 2008) and showed on the Figure 3.

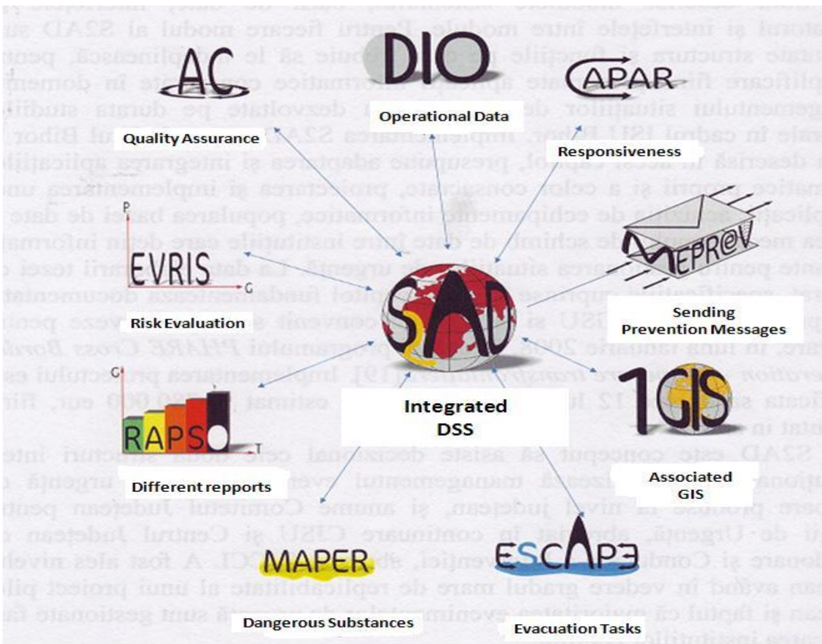

Figure 3. Integrated DSS for Emergency Management: S2AD (from (Zoicas C, 2008))

The components of the Integrated DSS for Emergency Management are:

EVRIS **-** evaluation of the risk associated to emergency events. This component is dedicated to the recording of every identified emergency event and of the estimated effects for pre-defined values of parameters describing dangerous event in a database. Data about the probability to reach of these dangerous values are also recorded. This component enable the interrogation of database configuring the parameters which describe impeding event, giving also an imagine of the degrees of associated effects.

MEPREV – prevention messages concerning emergency events.

10GIS – Associated GIS. Typically, emergency management depends on large volumes of accurate, relevant, on-time geo-information that various organizations systematically create and maintain. During emergencies, GIS enables emergency managers to quickly access relevant data about an affected area. The geospatial aspects may be explicit, such topographic maps, providing background information, or implicit, e.g. demographic data about population distribution in an affected area. In the same way either dedicated tools are used to analyze or incorporate geospatial aspects or the information is integrated via interoperable GI components or GI services in a specific emergency management application. Types of data usually needed in emergency management can be classified as follows (Balaji D, Sankar. R, Karthi. S, 2002): data on the emergency phenomena, their location, frequency, magnitude and so on; data on the environment in which the disastrous events might take place: topography, geology, geomorphology, soils, hydrology, land use, vegetation and so on; data on assets that might be destroyed if the event takes place: infrastructure, settlements, population, socioeconomic data and so on. At present the *Emergency Situations Inspectorate "Crisana" of Bihor County*, *Romania* using an "in house" system for particularly GI management and is part of *Oradea Local GIS Consortium.*

MAPER – dangerous substances. Mainly task of this component is to identify the characteristics of dangerous substances and estimate the effects of possible accidents involving dangerous substances. This component manages also the data concerning commercial societies that stores transport or generate the dangerous substances.

ESCAPE – evacuation in emergency situations. This component give the possibility to elaborate the evacuation plans for the affected localities, their re-evaluation and updating if necessary, elaboration in real time of an evacuation plan if necessary as well.

CAPAR **-** responsiveness. The design of this component is around of "support function" having as task to quickly provide the answers of the questions such as: Who is responsible for population's evacuation? Which and what available quantity of absorbents? How many devices for recovery are available?

RAPSO – different reports about various situations. At *Emergency Situations Inspectorate "Crisana" of Bihor County*, *Romania* is a complex application for collecting and processing of the data about the effects of sorely emergency situations.

AC – Quality Assurance. This component gives to the users the possibility of improvement. One of the modules, DQAT, developed for five languages, give the access to their four sections: prepare, adjust, evaluate and practising.

DIO – Operative Data.

A prototype of the Integrated DSS for Emergency Management has been developed at *Emergency Situations Inspectorate "Crisana" of Bihor County*, *Romania,* using the option for "in house" development software and based on user interface design idea described on the next section.

User Interface Design

One of the lessons learned during the international exercises was that the people don't have to wait in line during an evacuation. The TEVAC software system was designed based on this principle, the user interface being identical with the form filled by the evacuated people (Figure 4).

Also, in order to speed up the registration process predefined lists (drop down lists) and predictable writing functions were used.

Using a network of four computers - 160 persons were registered in about 60 minutes, the necessary time to input data for one person being about 90 seconds (Sandu L.). Using large open spaces, as is the sport hall and the proper organization of the space, avoided crowding in the registration area and during the evacuation process in general.

After the evacuees had been registered, the TEVAC ”repartition for accommodation” module - quickly generated the repartition lists and according to this list the evacuees were sent to the accommodation centres.

Before the repartition process starts it is possible to visualise the current situation of the available rooms and the status of the people who were not placed yet.

The default method prioritizes the repartition of relatives in order to regroup the families; the next rule is to accommodate women and elder people downstairs, then to group people by their residence in order to form mutual interest communities.

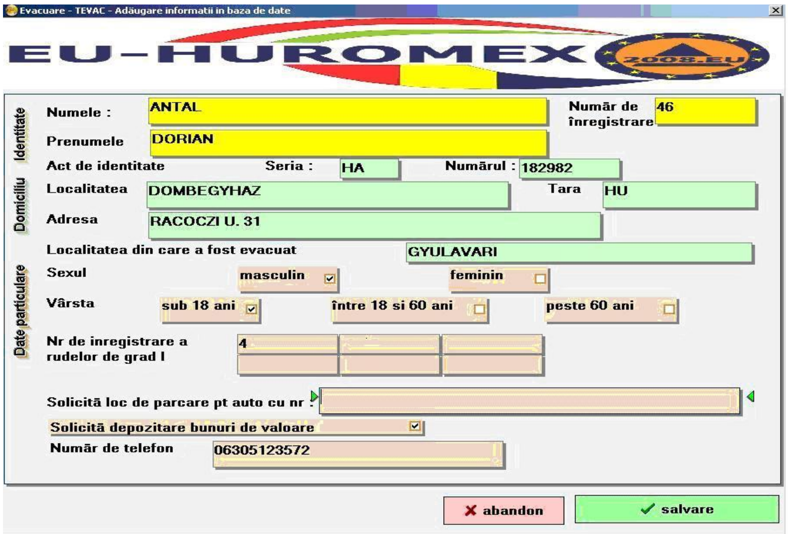

Figure 4. The user interface is similar with the registration form

Searching Features

The TEVAC software system also played an important psychological role by allowing relatives to find each others, using the database created during the registration process.

The software system allows advanced searching features including the use of geospatial criteria (search by consecutive filtering of fields, search by the value of a field, or by one part of a text in all fields).

“Search by filling in the filters” method is used when details about the searched person are known and consist in filling-in the filter fields, as shown in Figure 4 (e.g. Registration number, name, surname, etc.). This method can generate complex reports such as:

- *The list of all women distributed for accommodation, being over 60 years old, evacuated from Calarasi and having the first name Georgeta*
- The number of the persons who requested to store valuable goods.

The “Advanced search” method is used only when general information is known. For example, we do not know whether Vladimir is the name or the surname, the person is living in Galați or is evacuated from Galati only.

The “complex search” method is used when operative reports are needed. The method can generate complex reports by combining the *advanced search* with the *filling the filter* method. For example a list of all children without relatives in the camp and which were evacuated from Galati without having the residence in this city can be generated at the moment of departure from the evacuation camp.

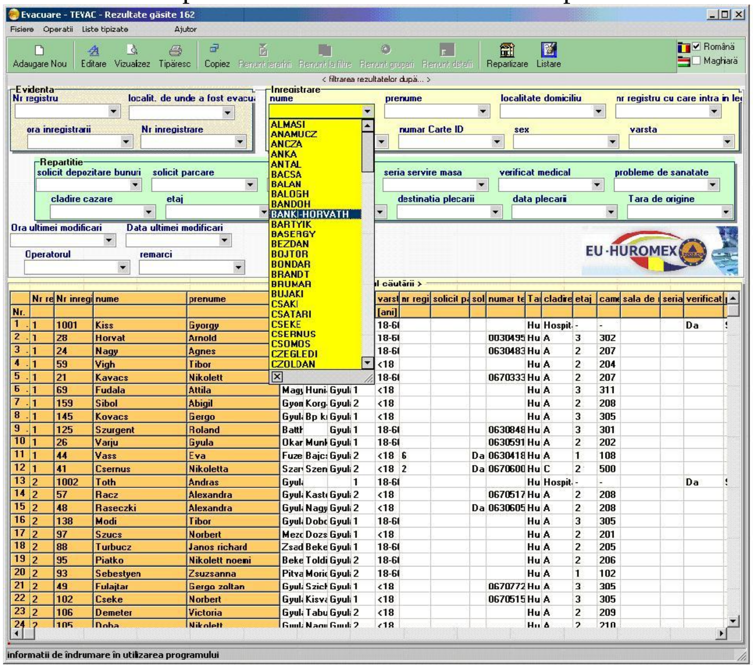

Figure 5. The software has complex searching features such as ”*Search by filling in the filters*” method

Discussions and future works

"*Solving large-scale evacuation problems is overwhelming*" (Yi-Chang Chiu). "*No one can just sit down with a map and draw lines and figure out the best answer to problems like these.*" (Yi-Chang Chiu).

Starting from April 2009, the TEVAC software system is used by all Emergency Situations Inspectorates all over Romania.

The lessons taking into account for next generation of TEVAC software system are:

- Threat must be detectable;
- Geographical data must be immediately available (Zoicas C., 2005);
- Correct positioning of equipment and personnel could avert the disaster.

Three major issues are especially critical:

- Advanced planning to identify and map those areas at risk is critical (Zoicas C., 2008);
- Advanced modelling of those areas considered at high risk;
- Real time capabilities are needed to track an event and deploy assets.

Future works

One of the critical problems is that the needed spatial and non-spatial data is usually geographically dispersed and stored in heterogeneous databases. The new generation of information systems including GIS should be able to solve semantic heterogeneity (Fonseca F., 2001).

Another problem consist on the fact that an Integrated System for Emergency Management is a multidisciplinary approach and is based and have to be based on the new information technologies (GIS, Web services, ontology, semantic integration), expert’s knowledge about structure and processes in the hazard management system, hazard emerging and possible effects on living environment, as also combine the knowledge of expert’s working in different domains. This will improve the process of emergency management.

The new models and services will be specialized for application in involved organizations and public services. So, the solution efficiency provided by proposed system will be especially valuable for all local community and local authorities from Romania.

The advantages of successful information integration in emergency management GIS applications are obvious for many reasons (L. V. Stoimenov, A. Lj. Milosavljević, and A. S. Stanimirović, 2007):
• Quality improvement of data due to the availability of large and complete datasets.
• Improvement of existing analysis and application of the new analysis.
• Cost reduction resulting from the multiple use of existing information sources.
• Avoidance of redundant data and conflicts that can arise from redundancy.

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紧急行动中心的空间设计

——1995 年坂神地震以来日本的相关进展

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【摘要】一般的操作图像对有效的应急管理来说是必要的，它的核心是应急操控中心，这个中心负责收集和总结应急响应的相关信息，并为应急反应中获取智能信息。

在日本，一些具有先进应急管理能力的地方政府都建立了他们自己的应急操控中心，来收集灾害信息，并与一些决策者共享这些灾害信息，决策者包括政府官员、高级官员等。应急操控中心的核心是一个会商大厅，这个大厅具备高科技的信息收集系统和视频会议系统。然而，在现实的应急响应时期，这种类型的应急操控中心存在一些问题：1）获取信息系统在现实应急中获取信息是很难的，2）对于应急响应者来说指挥应急行动没有足够的空间。

这篇论文通过成功的管理一个应急响应的个案来阐明一个适当的空间规划对于一个应急操控中心的作用。

这些研究实例都来自日本，包括 2004 年新泻洪水、2004 年新泻地震和 2007 年新泻地震。

因此，基于信息计算机系统概念的空间，包括命令，计划，后勤，资金和行动几方面，能有效管理一次应急响应，2）一个应急操控中心，所有的应急响应人员在一起工作，是一次基于普通图像操作的应急响应成功与否的关键。

【关键词】紧急行动中心；速度通用行动构想；事故管理系统

SPACELAYOUT OF EMERGENCY OPERATION CENTERS FOR EFFECTIVE EMERGENCY RESPONSE

JAPANESE INNOVATIONS FROM THE 1995 KOBE EARTHQUAKE TO PRESENT

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Keywords

Emergency Operation Centre, Common Operational Picture, Incident Management System

Abstract

Common Operational Pictures (COP) are essential for effective emergency management, and at their core is an Emergency Operation Center (EOC), which collects and summarizes information about emergency response as well as gathers intelligence for emergency response. In Japan, several local governments with advanced emergency management established their EOCs to collect and share damage information with decision makers such as the governor and high-ranking officials where the core was an executive meeting room with high tech damage collection systems and an audio visual system. However, during real emergency responses, this type of EOCs have several issues: 1) systems to collect information about the actual response are unavailable and 2) there is insufficient space for emergency responders to conduct the emergency operation. This paper clarifies an appropriate space layout for an EOC to successfully manage an emergency response using case studies on how the old type of EOC was overhauled. These case studies are all from Japan and include 2004 Niigata Flooding, 2004 Niigata Earthquake, and 2007 Niigata Earthquake. Consequently, it is determined that 1) space based on the ICS concept, which includes command, planning, logistics, finance, and operation, could effectively manage a good emergency response, and 2) an EOC where all the responders work together could be the key to a successful emergency response based on COP.

Introduction

Common Operational Pictures (COP) are essential for effective emergency management. To establish COP, an Emergency Operation Center is a core facility to collect and summarize information about the emergency response. In Japan, several local governments with advanced emergency management have established EOCs using the lesson learned from the 1995 Kobe earthquake, which is disaster responders need to collect and share “damage information” with decision makers, including the governor and high-ranking officials. The core function of such EOCs is an executive meeting room housing a high tech damage information collection system as well as an audio visual system. However, during a real emergency response, this type of EOC has several problems such as 1) it is unable to collect information about the actual responses and 2) there is insufficient space for emergency responders to conduct real emergency operations. (Motoya, Y., Maki, N., Higashida, M, Hayashi, H., 2006: 4)

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Hence, this paper proposes establishing an EOC with sufficient space to successfully manage an emergency response with COP by tracing the revision process of EOC space layouts in Japan since the 1995 Kobe Earthquake.

Theory and Method

Analysis based on the ICS organizational structure

Incident Management System, ICS, is a standard emergency response system. ICS was installed as the national emergency response system in the United States as part of the overhaul of the emergency management system after the 9-11 terrorist attacks in 2001 (DHS 2008:5). ICS was originally developed through the lessons learned from fighting California wildfires in the 1970s (Erik Auf der Heide 1989: Chapter7). In 1993, the state of California officially authorized ICS as their emergency response system, which was called Standardized Emergency Management System (SEMS) and was from the lesson of the 1991 Oakland Fire.

ICS has numerous advantages, including unity of command, common terminology, and span of control. However, this article analyzes the special formation of an EOC based on the organizational structure described in ICS, which includes 1) Command, 2) Operation, 3) Planning, 4) Logistics, and 5) Finance and Administration (Fig. 1). Based on the hypothesis that the EOC spatial formation is a reflection of the organizational structure, all EOC arrangements are analyzed through the ICS organization.

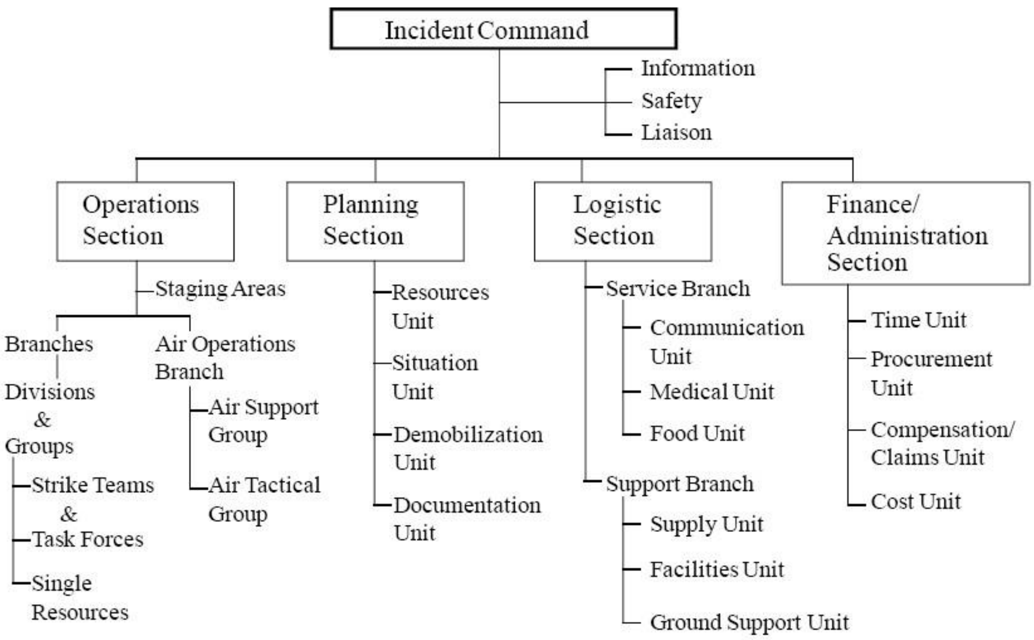

Fig. 1 ICS organizational structure (EMI 2010)

Case studies

Analysis of this article is based on collected data on EOC spaces for 1) organizations with advanced emergency management such as California in the United States, Hyogo, Shizuoka, and Tokyo in Japan as well as 2) organizations that conducted real emergency management operations such as Ojiya and Sanjyo in Japan.

In 2004, data was collected in California as well as in Japanese EOC surveys, while the impacted jurisdiction survey was conducted in 2005-2006.

EOCs in California

Since 1993, the state of California has used an ICS, called SEMS, for their emergency responses. Their standardized emergency response system has the support of emergency operation personnel in other organizations, especially since they all use the same operation system and staff from other organizations can easily assist with an emergency response.

EOCs in California are designed based on the ICS concept and a standardized space layout. Thus, the state, county, and city governments all use the same EOC plan. Figure 2 depicts the basic concept of their EOC plan for the state, county, and municipality governments.

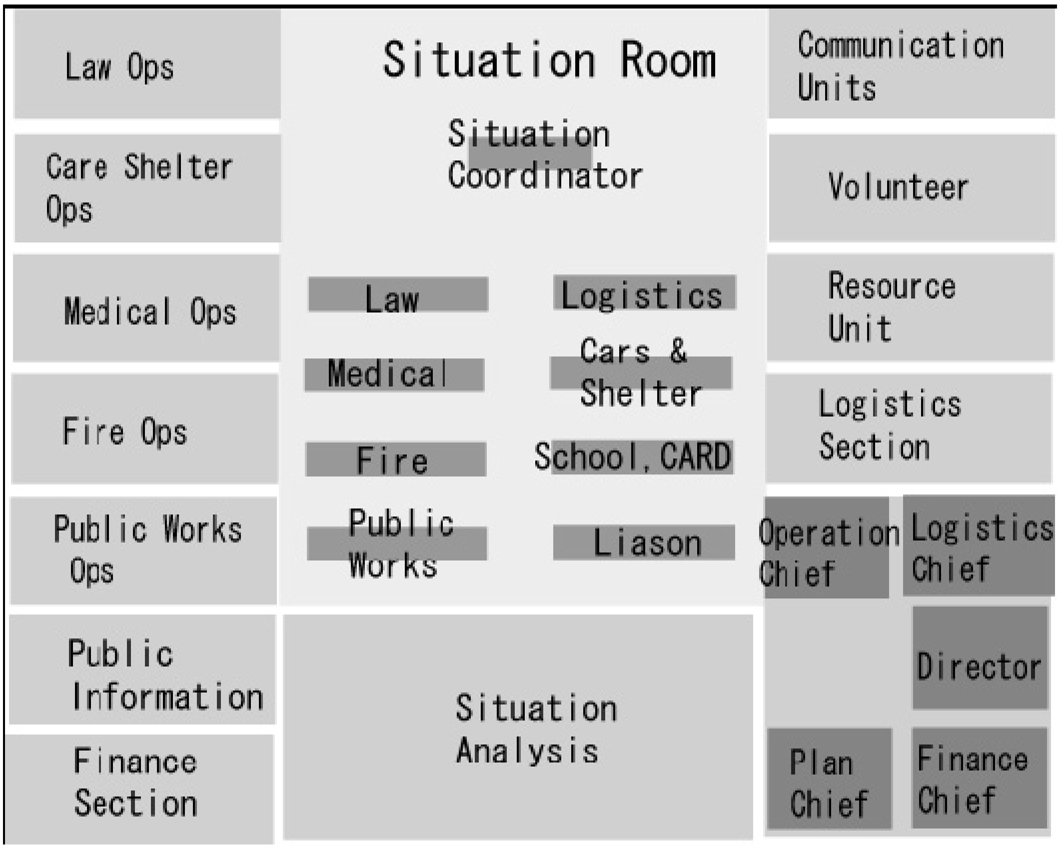

Fig. 2 Concept plan of EOC based on ICS

A crucial component of emergency response is that all the responding personnel have a COP. Thus, all the information about the emergency situation should be shared among responding personnel and decision makers. This EOC layout uses a simple mechanism to ensure COP; all the responders work in one room, called the "situation room" so that all the information about emergency responses by various organizations is automatically shared.

In addition to working in the same room, below are other characteristics of EOCs based on the ICS concept: 1) State, county, and city governments employ the same EOC plan as it eases mutual aid among organizations. 2) The EOC contains the five functions of ICS: command, operation, plan, logistics, and finance & administration. 3) Each EOC has a small room or area for each ICS function because in the United States, all emergency operation is conducted in an EOC. 4) Mass media people have access to the press room, but have limited access to the EOC, itself. Some EOCs have a press conference room with a view of the situation room. 5) Sections and room to monitor mass media information are prepared.

Japanese EOCs after the 1995 Kobe earthquake

Lessons from the 1995 Kobe Earthquake

The 1995 Kobe earthquake killed 6,434 people. One big lesson for disaster managers in Japan was that they cannot initially collect information about hazards and damage, and delay setting up emergency operations. Thus, after the Kobe earthquake, the national government established the world's densest seismometer network as well as developed an early damage estimation system capable of approximating human causalities and building damage within several minutes using data from the seismometer. Local governments also established a disaster information system with an early damage estimation system, damage data collection system from municipal governments, and developed an image transmission system from helicopters. Although the Kobe earthquake provided many lessons about information collection as well as damage sustained by governments and critical infrastructure (such as the importance of mission tracking, dissemination of information about relief and recovery activities), only the importance of hazard and damage data collection was spotlighted.

EOCs based on the 1995 Kobe Earthquake Lessons

EOCs were constructed based on the lesson from the 1995 Kobe earthquake and were intended to collect damage information. The priority of the EOC design was sharing damage information among decision makers. Thus, the core of the EOC was executive meeting rooms equipped with an audio visual system connected to a hazard information network, early damage estimation system, and heli-television, so that decision makers could determine the an appropriate emergency response based on damage information. Figure 3 shows the layout of the Hyogo Prefecture Government's EOC, which experienced disaster response of the 1995 Kobe Earthquake. Instead of one large executive meeting room to make decisions, a shortage of operation rooms for emergency responders is expected.

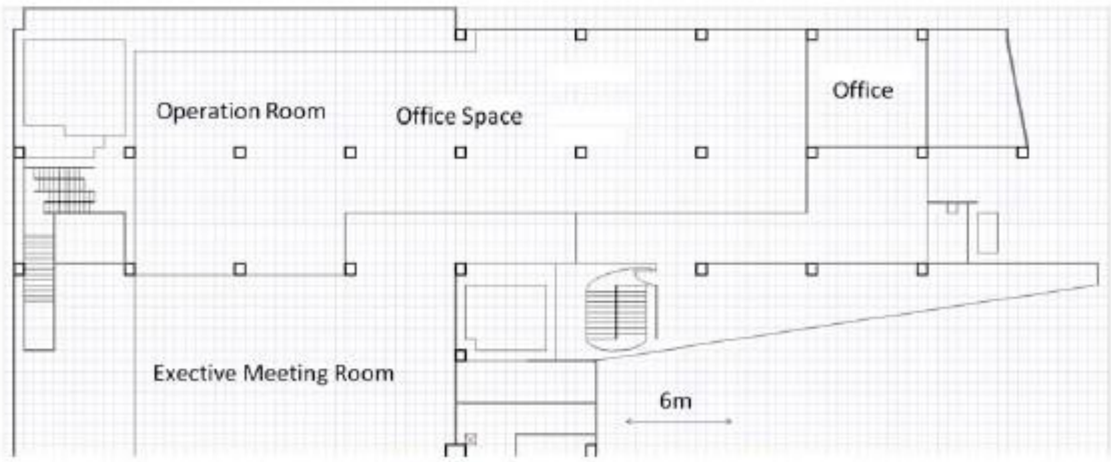

Fig. 3 EOC of Hyogo Prefecture Government, which was government affected by the Kobe earthquake

EOCs in 2004 disasters

2004 Niigata flood disaster

On July 13, 2004, Niigata and the Fukui area suffered from heavy rain and flooding. Figure 4 shows the EOC plan of Sanjyo City in Niigata during the flood disaster. The EOC function of Sanjyo City was analyzed based on ICS functions. One problem was that Sanjyo City's EOC lacked an "operation" function during the disaster response in 2004. Additionally, the EOC layout concentrated on damage information collection and decision making.

However, after the 2004 flooding disaster, Sanjyo City revised their EOC plan to reflect the lessons learned (Fig. 5) Their revisions included 1) adding an "Operation function" into EOC, 2) reducing the size of meeting space for executives, and 3) revising the EOC to include all five functions of ICS (command, operation, plan, logistics, and finance & administration).

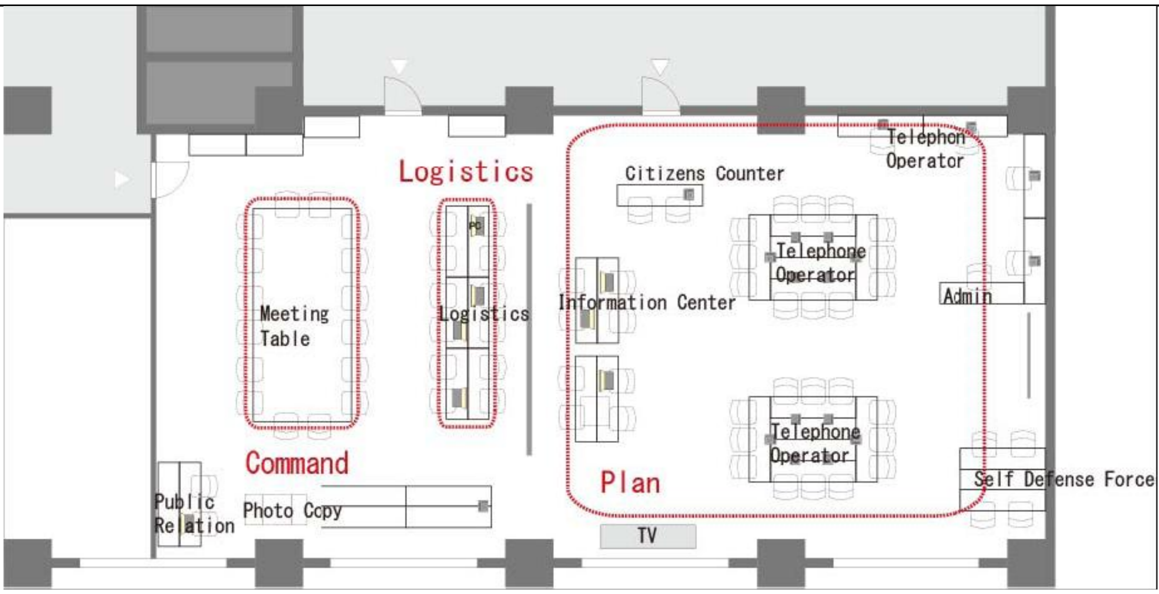

Fig. 4

EOC of Sanjyo City during the flooding disaster

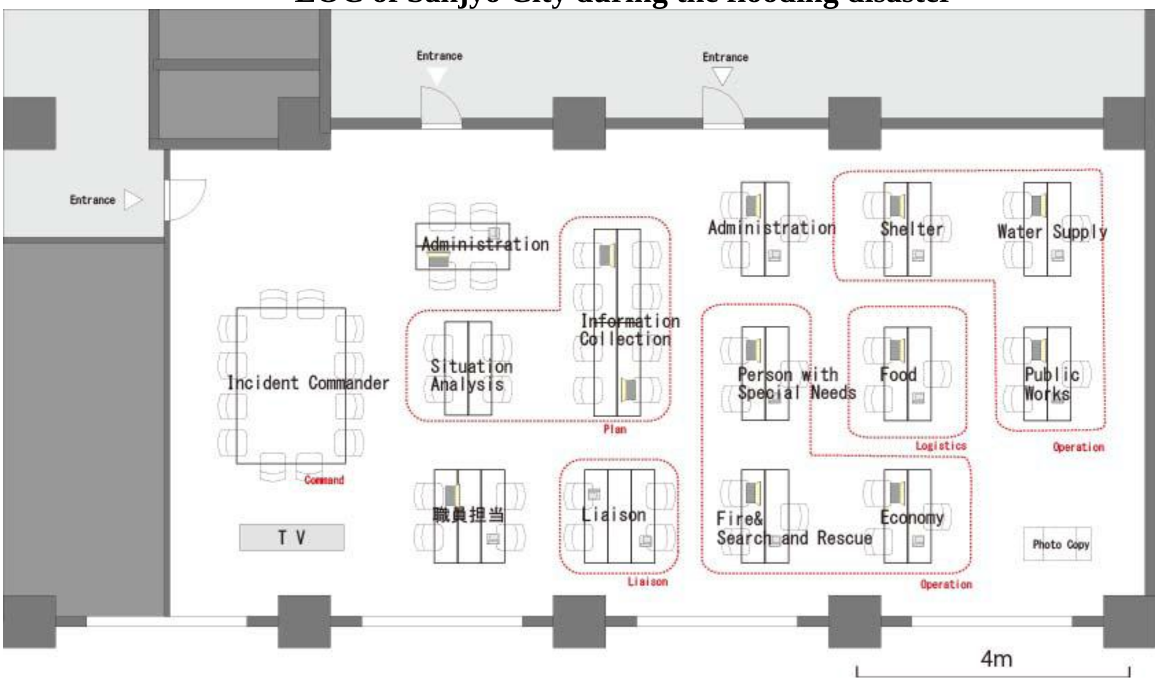

Fig. 5

EOC revision after the flooding disaster

2004 Niigata Chutes Earthquake disaster

On Oct. 23, 2004, the Mid-Niigata area was hit by a M6.8 (JMA) earthquake. Ojiya City suffered severe damage. Figure 6 shows the layout and picture of Ojiya City Government's EOC. Although the layout of EOC looks similar to the layout of a meeting room, it was used as the actual operation center shown in the picture. Unlike Sanjyo City, the EOC contained the operation function of the ICS.

All the collected information was shared by posting it on the walls, and nearly all the directors, such as the persons in charge of shelter, construction, etc. were in the EOC.

However, information about logistics was missing because the operation chief of logistics was not present.

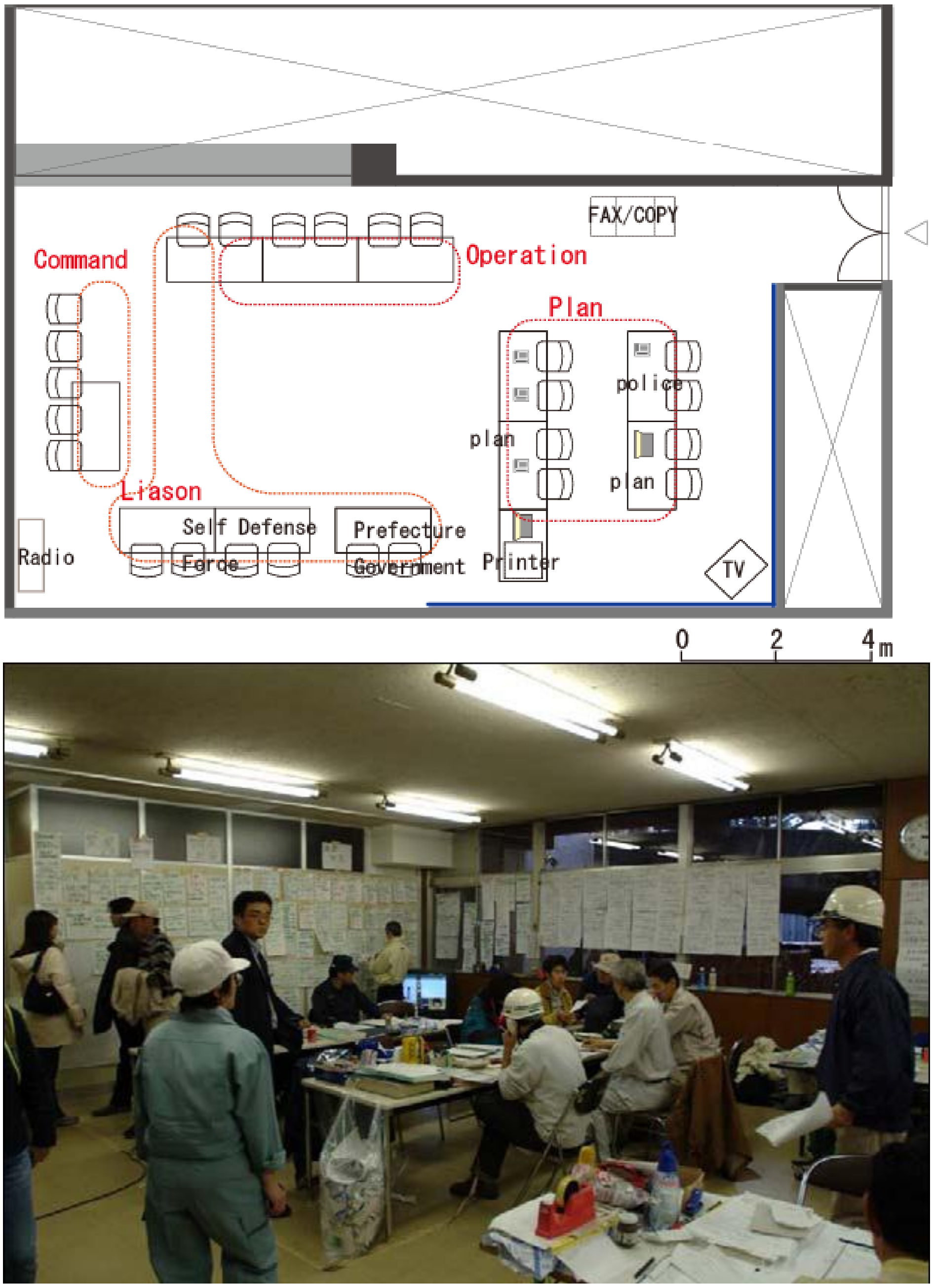

Fig. 6 EOC of Ojiya City

Collecting information about operations

The lesson from the Kobe earthquake was the lack of information about damage. Thus, EOCs were designed at facilities to collect “damage” information. However, in addition to information about damage, as demonstrated by the cases in the 2004 disasters, a real disaster response requires information about operations and what the government is doing to support victims.

Organizations that have real disaster operation experience enhance the EOC’s operation, as demonstrated during the Sanjyo City disaster. Additionally, the EOC should also have liaisons from operation sections such as shelter, food, water supply, construction, etc., and these liaisons should be managers to ensure accurate information is coming into the EOC.

Figure 7 shows the layout of the EOC space based on these case studies. There are four items that should be noted. 1) The Plan section is in between Command and Operation and Logistics because the Plan section collects and summarizes information from Operation and Logistics and then distributes this information to Command. 2) Mass media is not allowed in the EOC. 3) EOC is not executive meeting space. The Department Operation Center (DOC) is established in the operation sections.

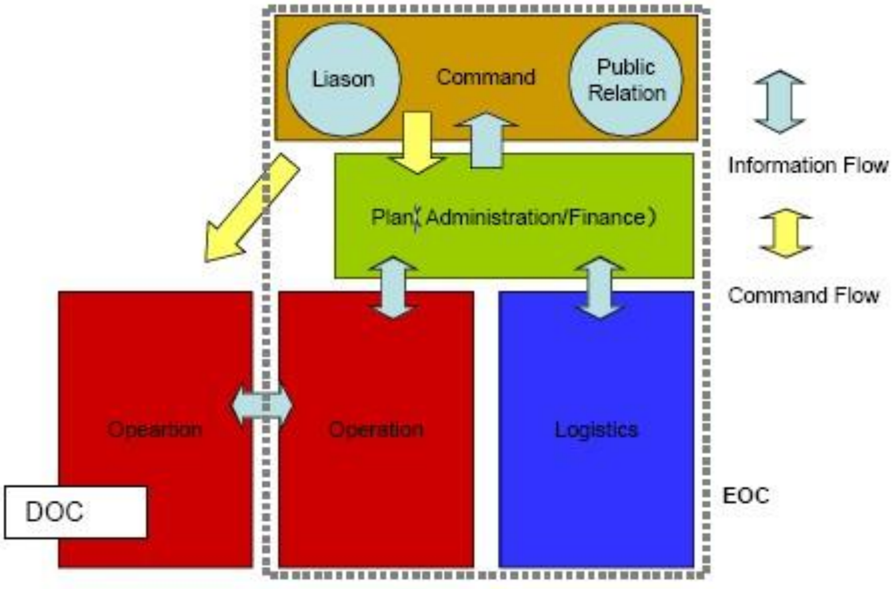

Fig. 7 Layout of EOC based on case studies

Discussion

This paper discusses the ideal EOC space layout based on case studies in Japanese EOCs. We are disseminating this EOC concept in lectures for emergency managers in Japan, and EOC layouts are changing from executive meeting type spaces to operation type spaces. Figure 8 is a picture of the Niigata Prefecture Government's EOC, which shows that all personnel in charge of disaster response work in one large room. This layout ensures that information is automatically shared among disaster responders and decision makers, and that the EOC works on an emergency response based on COP.

Fig. 8 EOC of Niigata Prefecture Government during the 2007 Niigata Chuetsu earthquake

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基于受灾民众随机样本社会调查的生活重建流程阐明方法研究

恢复与重建日程表

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【摘要】在日本发生的三次大地震，1995 年 1 月 17 日的 Kobe (Hanshin-Awaji)地震，2004 年 10 月 23 日的 Mid-Niigata 地震，2007 年 7 月 1 日的 Chuetsu-Oki 地震，形成了我们的受灾民众调查基础。

我们的研究小组在三次大地震中实施了周期性的随机样本社会调查（类似于固定点调查观察）。我们使用一些阐明长期生活重建流程的研究成果，对灾民进行了询问。论文中我们对“恢复与重建日程表”研究成果进行了讨论，对我们研究的地震灾民在重建其破碎生活中的经历阐明了其流程。

我们在三次地震随机调查的日程表结果基础上，检查了具体推荐的日程表所定义的大部分流程。我们得出的结论是：①灾民的行为模式被发现。我们修改的时间点是：事件发生后 10 小时，100 小时（4 天），1000 小时（2 个月），10000 小时（1 年），100000 小时（10 年）；②恢复与重建日程表在阐述恢复与重建流程上有高度的重复性；③排除灾难大小与模式，灾后在各时间段，流程总体上可以被识别。

【关键词】随机社会调查；生活重建流程；灾民行为

DEVELOPMENT OF THE METHOD OF CLARIFYING THE LIFE RECONSTRUCTION PROCESS BASED ON THE RANDOM SAMPLED SOCIAL SURVEYS OF THE VICTIMS

RECOVERY AND RECONSTRUCTION CALENDAR

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Keywords

Random Sampled Social Survey, Life Reconstruction Process, Victims' Behaviour

Abstract

Three major earthquake disasters that occurred in Japan formed the basis of our surveys of disaster victims, the Kobe (Hanshin-Awaji) Earthquake that struck on January 17 1995, the Mid-Niigata Earthquake that struck on October 23 2004 and the Chuetsu-Oki Earthquake that struck on July 16 2007.

Our research team conducted random sampled social surveys periodically (like fixed-point survey observation) in the areas affected by three earthquake disasters. We asked the victims using some scales that were developed for clarifying the long-term life reconstruction process. In this paper we discussed "recovery and reconstruction calendar" scale we developed for clarifying the process that earthquake victims undergo in rebuilding their shattered lives.

We have examined the generality of the process clarified by the proposed calendar concretely, based on results for the calendar in random surveys on the three earthquakes. We concluded that (1) the patterns of victims' behaviours are found, which were changed at the points of 10 hours, 100 hours (4 days), 1,000 hours (2 months), 10,000 hours (1 year) and 100,000 hours (10 years) after the event occurred, (2) the recovery and reconstruction calendar is highly reproducibility in clarifying the recovery and reconstruction process and (3) generalization can be recognized in this process in time phases after disasters despite differences in disaster size and mode.

1. Introduction

A gigantic disaster not only caused physical damage to cities' development, but also had significant psychological and social impacts upon the bodies, minds, and lives of disaster victims, local community relationships, organizations, groups, and social systems. As a result of a major disaster, victims may sustain both person and material damage, and struggle to carry on with their ordinary lives as normal. The process for recovering everyday life while people and society adapt to a post-disaster environment is called the disaster process or life recovery/reconstruction process if the lives of people are brought into focus. If the disaster process is understood objectively, the situation and needs of victims and their society can be realized by answering the following questions, which problems occur for whom in what sequence, and how these problems can be solved.

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2. Five time phases following the occurrence of the disaster

We have been studying the life reconstruction processes of victims of the Kobe (Hanshin-Awaji) Earthquake that struck on January 17 1995, and, in particular, how the disaster victims established new daily lives in the post-disaster environment. We conducted random mail surveys of the Kobe Earthquake disaster area in 1999, 2001, 2003 and 2005. In these surveys, we verified the hypothesis that the feelings and behaviours of disaster victims change during five periods of time that are separated by five time axes: the day of the disaster (10 hours), two to four days (100 hours) after the disaster, two months (1,000 hours), the one year (10,000 hours) and the 10 years (100,000 hours) after the disaster. [1]

These five stages are defined as follows:

I. Disorientation phase – a period in which victims suffer from the impact of disaster so severely that they have difficulty in orienting themselves in the new environment.

II. Acceptance of new reality phase – a period in which victims accept damage rationally and undertake to adapt themselves to a new society based on a new order.

III. Disaster utopia phase – a period in which life resembling primitive communism forms based on social values different from those of ordinary times because of the paralysis of social function such as lifeline services.

IV. Reentry to everyday life phase – a period in which victims undertake to reconstruct their lives due to restoration of social infrastructures such as lifeline services.

V. Reconstruction phase – a period in which the most of the victims and organizations believe that the impact of the disaster is reconstructed and the society in the impacted area is recovered (figure 1).

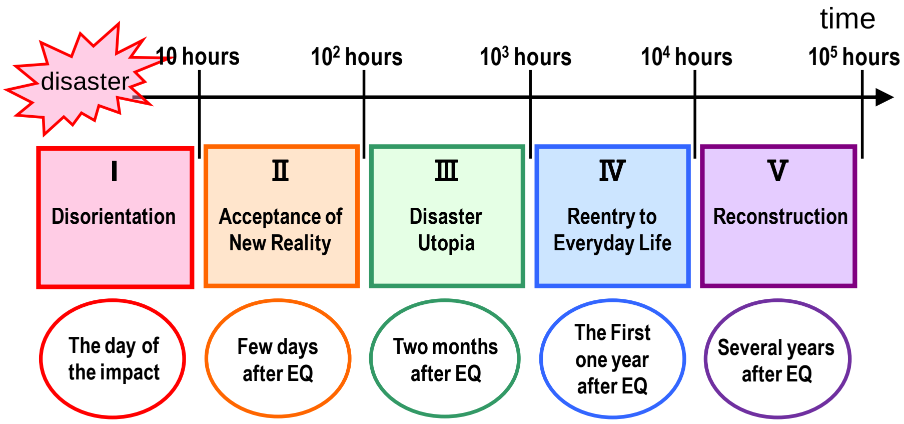

Figure 1. Five Stages after the earthquake

3. Implementation of Surveys

3.1. Three major earthquake disasters in Japan

Three major earthquake disasters that occurred in Japan formed the basis of our surveys of disaster victims, the Kobe (Hanshin-Awaji) Earthquake that struck on January 17 1995, the Mid-Niigata Earthquake that struck on October 23 2004 and the Chuetsu-Oki Earthquake that struck on July 16 2007. Table 1 shows the overview and figure 2 shows the characteristics of these disasters.

Table 1. Overview of three earthquakes

	The Kobe (Hanshin-Awaji) EQ in 1995	The Mid Niigata Prefecture EQ in 2004	The Chuetsu-oki EQ in 2007
Seismic Intensity (JMA)	7 (M7.3)	7 (M6.8)	Upper 6 (M6.8)
Impact Area	Density populated urban area (Hyogo prefecture)	Remote and isolated area among mountains (Niigata prefecture)	Local cities area (Niigata prefecture)
Casualties	6,437	68	15
Injuries	43,792	4,805	2,346
Housing Damage	about 650,000	about 120,000	about 44,000
Emergency Shelters	over 1,200	603	116
Evacuees	over 300,000	about 103,000	about 12,500
Temporary Housings	48,300	3,460	1,222
Public Collective Housings for victims (number of houses)	about 40,000	493	178

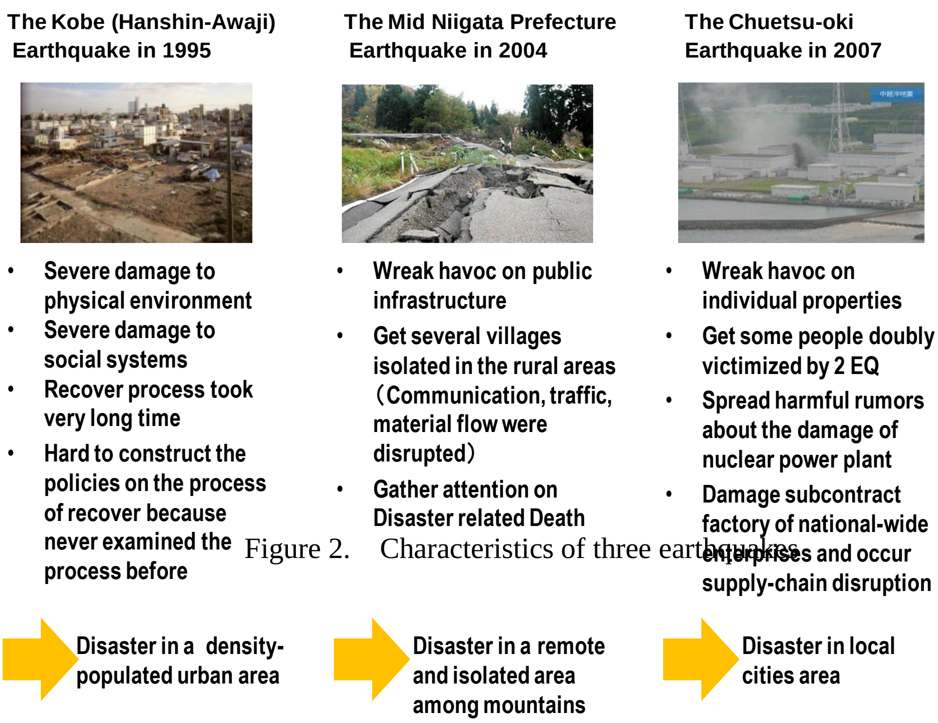

Figure 2. Characteristics of three earthquakes

3.2. Recovery and Reconstruction Calendar

Our research team conducted random sampled social surveys periodically (like fixed-point survey observation) in the areas affected by three earthquake disasters. (Table 2) We asked the victims using some scales that were developed for clarifying the long-term life reconstruction process. In this paper we discussed "recovery and reconstruction calendar" scale we developed for clarifying the process that earthquake victims undergo in rebuilding their shattered lives.

Table 2. Survey overview of three earthquake disasters

	Kobe Survey in Jan. 2003 and 2005	Mid-Niigata Survey in Mar. 2009	Chuetsu-oki Survey in Mar. 2009
Earthquake occurred in	17 January 1995	23 October 2004	16 July 2007
Surveyed Area	Areas where 7 on the seismic scale was recorded and gas was stopped + Kobe City Kita ward and Nishi ward	Areas in Nagaoka City, Ojiya City, and Kawaguchi Town, where 6 lower on the Japanese seismic scale was recorded	Areas in Kashiwazaki City, Izumozaki Town, and Kariwa Village, where 6 lower on the Japanese seismic scale was recorded
Surveyed person	Man and woman 20 years or older	Man and woman 20 years or older	Man and woman 20 years or older
Sampling	Sampled from resident register using stratified two-stage sampling (165 points, 20 residents per point)	Sampled from resident register using stratified two-stage sampling (69 points in Nagaoka City, Ojiya City, and Kawaguchi Town, 20 residents per point)	Sampled from resident register using stratified two-stage sampling (56 points in Kashiwazaki City, Izumozaki Town and Kariwa Village, 20 residents per point)
Number of surveyed persons	3,300 (in 2003), 3,300 (in 2005)	1,380	1,120
Number of effective answers	1,203 (in 2003), 1,028 (in 2005)	619	483
Rate of effective answers	36.5% (in 2003), 31.2% (in 2005)	44.9%	43.1%
Method of survey	Fill out questionnaire sent by mail and collect it by mail	Fill out questionnaire sent by mail and collect it by mail	Fill out questionnaire sent by mail and collect it by mail

We developed a recovery and reconstruction calendar for measuring overall reconstruction quantitatively for victims and stricken areas, clarifying the disaster process by ethnography interviews verified through quantitative examination. Milestones in recovery and reconstruction are mentioned in the social survey, questions ask when events happened and answers obtained. This set of procedures is called the recovery and reconstruction calendar. Table 3 shows questions. [1, 2]

Table 3. Items of recovery and reconstruction calendar

- Eleven items, which are milestones of ethnography survey findings as events marking restoration and reconstruction many victims experienced

① I understood the entirety of the damage.
② I felt safe.
③ I was prepared to have an uncomfortable life for a while.
④ Office/school have resumed.
⑤ Problem of housing was finally settled.
⑥ Personal financial situation was no longer influenced by the earthquake.
⑦ Everyday life settled down.
⑧ Local activity was restored.
⑨ I did not define myself as a disaster victim.
⑩ Local economy was no longer influenced by the earthquake.
⑪ Local roads were reconstructed.

4. Result of recovery and reconstruction calendar

4.1. Kobe earthquake

Figure 3 shows results of the 1995 Kobe earthquake disaster survey conducted in 2003/2005, eight/ten years after the earthquake. At 10 hours after the earthquake and disorientation phase, victims prepared to have an uncomfortable life for a while (the night of the day of the earthquake, 56.3%) and understood the entirety of the damage (on the morning of the day after the earthquake, 54.2%). Three weeks after the earthquake, they felt safe (50.1%). The percentage who answered office/school have resumed exceeded 50% one month (1,000 hours) after the earthquake when disaster utopia phase finished (54.1%) and 94.2% answered so 10 years after the earthquake (in the survey). Each percentage of those who answered everyday life settled down and problem of housing was finally settled exceeded 50% about half a year after the earthquake, which corresponds to reentry to the everyday life phase (55.3%, 52.2%). We supposed that many people felt that everyday life settled down by settling their housing problems.

The percentage of those who answered personal financial situation was no longer influenced by the earthquake exceeded 50% one year (10,000 hours) after the earthquake (59.2%). 76.9% answered so 10 years after the earthquake (at the survey). The percentage of those who answered I did not define myself as a disaster victim exceeded 50% one year (10,000 hours) after the earthquake (51.5%). 75.5% answered so in 2005 when the survey was conducted.

We also found that the number of respondents who felt local economy was no longer influenced by the earthquake exceeded the majority (52.6%) 10 years after the earthquake at the survey. In areas stricken by a catastrophic urban disaster, it can be seen that 10 years after the earthquake. The local economy had finally recovered from the earthquake's influence, indicating that response and measures would have to span up to a decade after a great quake to recover and reconstruct a modern society.

Although over 50% of victims no longer felt influenced, a look at individual life reconstruction suggests that over 40% still lived with the feeling that local society had not yet recovered from the disaster. This indicates the need for careful support in life reconstruction among individual victims for at least 10 years.

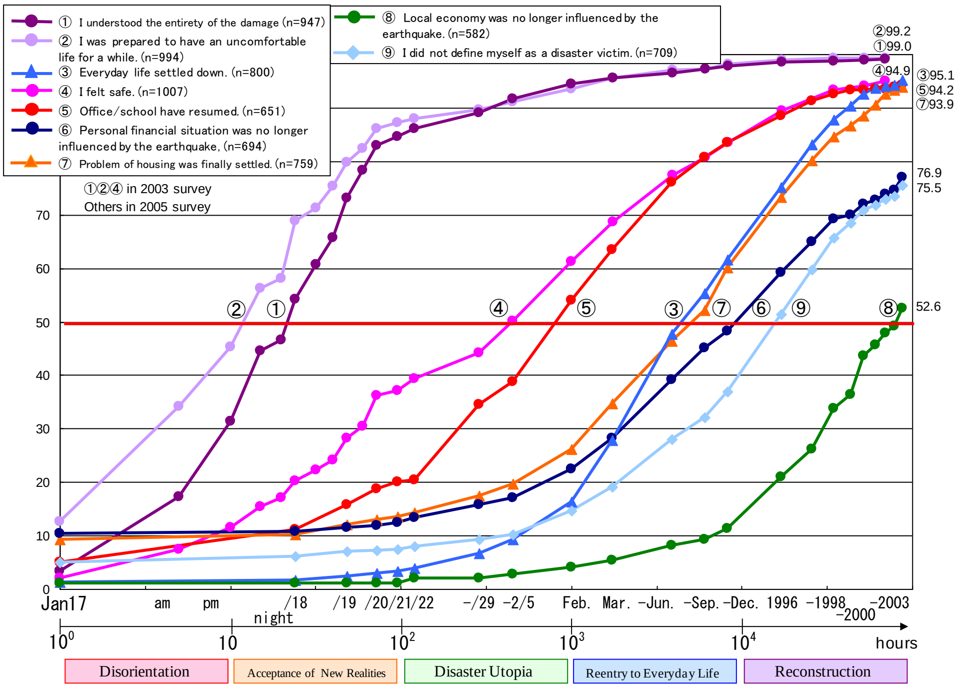

Figure 3. Recovery and reconstruction calendar (Kobe survey in Jan. 2003 and Jan. 2005)

4.2. Mid Niigata earthquake

Figure 4 shows the result of the 2004 Mid Niigata earthquake disaster survey conducted in 2009, five years after the earthquake. For I was prepared to have an uncomfortable life for a while, it took 10 hours (the day after the earthquake, 63.4%), which corresponds to the time for overcoming disorientation to understanding the disaster. It took a week for acceptance of the new reality phase to finish to understand damage (a week after the earthquake, 76.2%). It took more time to grasp the scale of damage, because the disaster occurred in a mountainous area far different than in the urban Kobe Earthquake. After two weeks, office and school began to resume rapidly and 51.7% answered that they had resumed two weeks after the earthquake.

For other questions, the percentage exceeded the majority of 1,000 hours after the earthquake when heavy winter snows began to melt in stricken areas. The percentage of those who answered I felt safe and everyday life settled and exceeded the majority in March 2005, about half a year after the earthquake (53.2%, 53.9%). From spring, the number of respondents who answered problem of housing was settled (about six month after the earthquake, 56.6%) and local activity was restored (six months after the earthquake, 58.4%) increased notably.

At one year after the earthquake, the numbers of respondents who answered personal financial situation was no longer influenced by the earthquake (about one year after the earthquake, 64.2%) and local roads were reconstructed exceeded the majority (66.5%). increased notably. It took two years half until the percentage of those who answered I did not define myself as a disaster victim (about two years after the earthquake, 62.6%). It took three years half until the percentage of those who answered local economy was no longer influenced by the earthquake (about three years after the earthquake, 64.4%). Even at the time of the survey, about five years after the earthquake, the percentage of those who answered local economy is no longer influenced by the earthquake is 78.2%, and I did not define myself as a disaster victim is 82.2%, suggest that it will take much more time to restore local economy and individual lives.

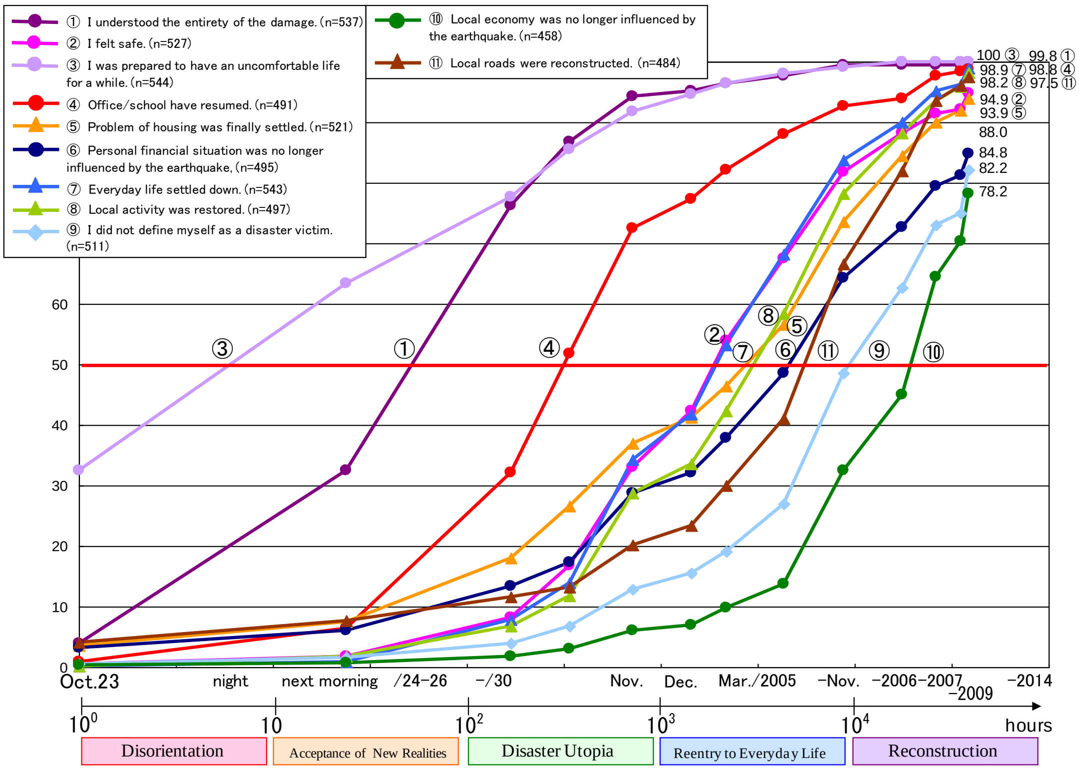

Figure 4. Recovery and reconstruction calendar (Mid Niigata survey in Mar. 2009)

4.3. Chuetsu-oki earthquake

Figure 5 shows the result of the 2007 Chuetsu-oki earthquake disaster survey conducted in 2009, one and a half year after the earthquake. At 10 hours after the earthquake and disorientation phase, victims prepared to have an uncomfortable life for a while (the night of the day of the earthquake, 69.8%). One week after the earthquake, they understood the entirety of the damage (one week after the earthquake, 80.4%) and two weeks after the earthquake, office/school have resumed exceeded 50% (two weeks after the earthquake, 54.4%). One month after the earthquake, they felt safe (55.5%). The percentage who answered everyday life settled down exceeded 50% two months when disaster utopia phase finished (51.5%).

In reentry to everyday life phase, problem of housing was finally settled exceeded 50% three months after the earthquake (51.7%). The percentage who answered personal financial situation was no longer influenced by the earthquake and local activity was restored exceeded 50% six months after the earthquake (57.1%, 59.1%).

The percentage of those who answered local roads were reconstructed exceeded 50% one year (10,000 hours) after the earthquake (59.6%). 82.2% answered so 1.5 years after the earthquake (at the survey). The percentage of those who answered I did not define myself as a disaster victim exceeded 50% one year (10,000 hours) after the earthquake (58.9%). 70.1% answered so in 2009 when the survey was conducted. We also found that the number of respondents who felt local economy was no longer influenced by the earthquake do not exceed the majority (48.0%) 1.5 years after the earthquake at the survey.

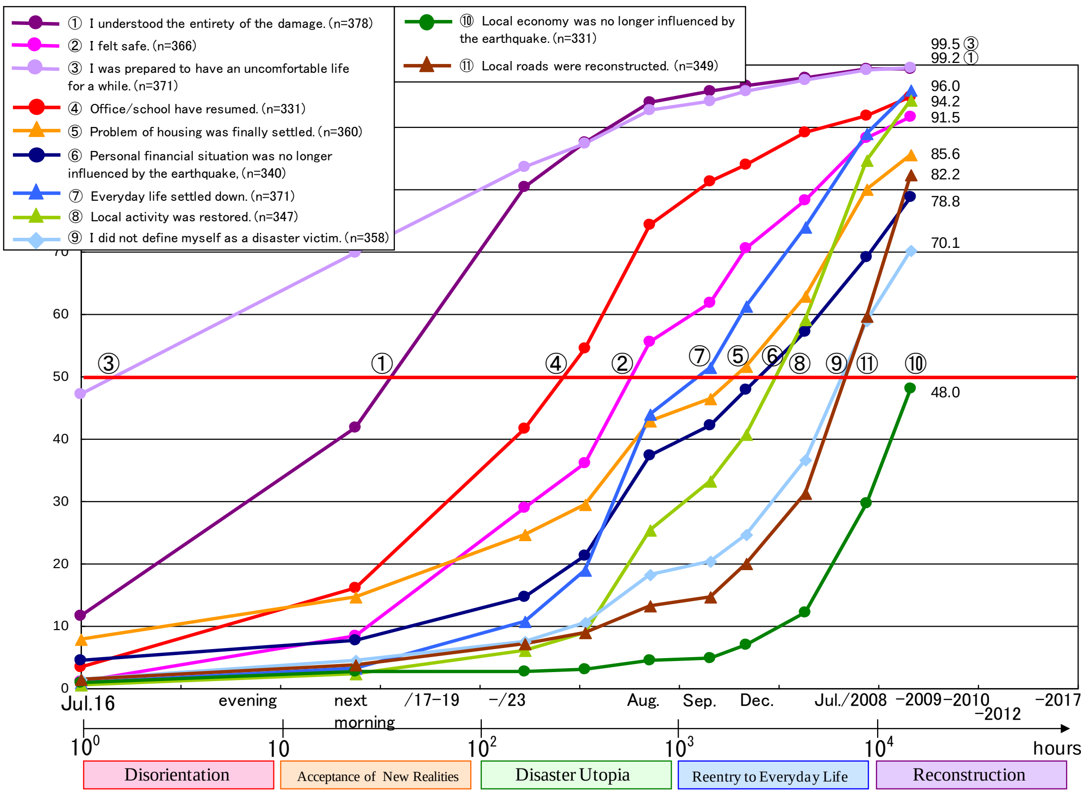

Figure 5. Recovery and reconstruction calendar (Chuetsu-oki survey in Mar. 2009)

5. Calendar reproducibility

To determine the calendar's reproducibility, whether the calendar could be understood by

respondents and answered similarly, other respondents sampled within the same surveyed areas were asked to answer the same questions multiple times.

Figure 6 shows results of overlapping 11 overlapping questions in surveys in 2006 and 2009 in the same areas surveyed in the Niigata Earthquake. Fine lines show results in 2006 and bold lines in 2009. We recognized many common points, for example, how the percentage of recovery and reconstruction rises in each item and the time when each item exceeds the majority.

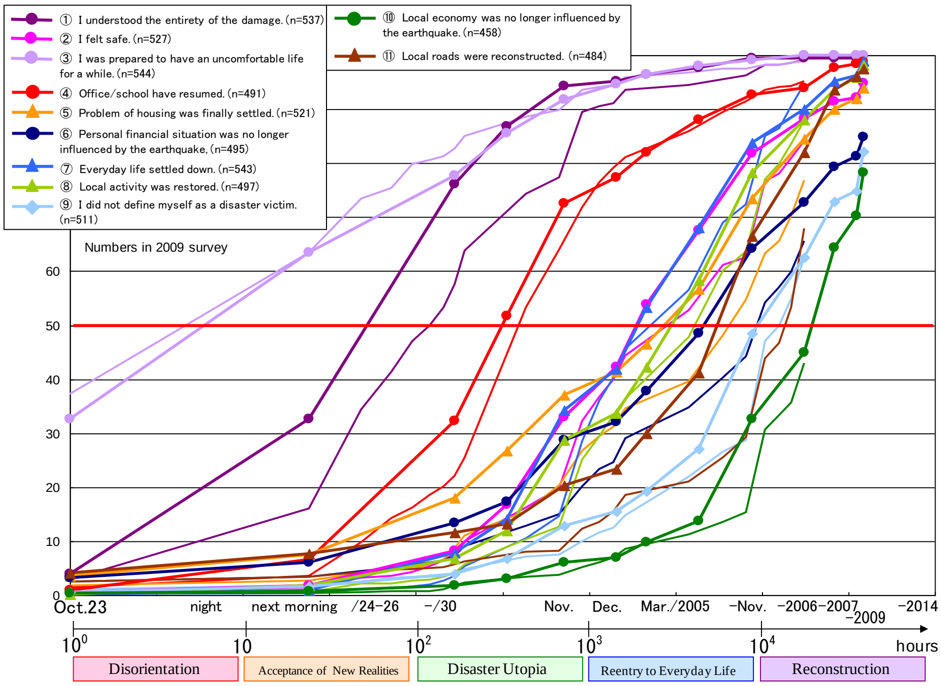

Figure 6. Recovery and reconstruction calendar

(Mid Niigata Survey; fine lines show results in Oct./2006 and bold lines in Mar./2009)

6. Comparison between the Kobe and the Mid Niigata earthquake disaster using recovery and reconstructing calendar

Reviewing the question of how multiple disasters can be compared and examined using the recovery and reconstruction calendar, we found that the recovery and reconstruction calendar in the Kobe Earthquake Disaster and that in the Mid Niigata Earthquake overlapped (Figure 7). In Fig. 7, fine lines with the letter K show results of the survey in the Kobe Earthquake and bold lines those of that in the Mid Niigata.

The process of life reconstruction in the Kobe Earthquake and in the Mid Niigata Earthquake showed many common elements despite is significant differences in damage scale and mode. For example, at 10,000 hours after the earthquake, the number of respondents who answered I did not define myself as a disaster victim exceeded the majority. This occurred about one year after either earthquake, so it appears important to take responses and measures against disaster for victims to return from emergency to ordinary life, setting the first anniversary as one objective. As for the item local economy was no longer influenced by the earthquake, the majority was exceeded finally about 10 years (100,000 hours) after the Kobe Earthquake, while the local economy was rapidly reconstructed by the earthquake five years after the Niigata Earthquake.

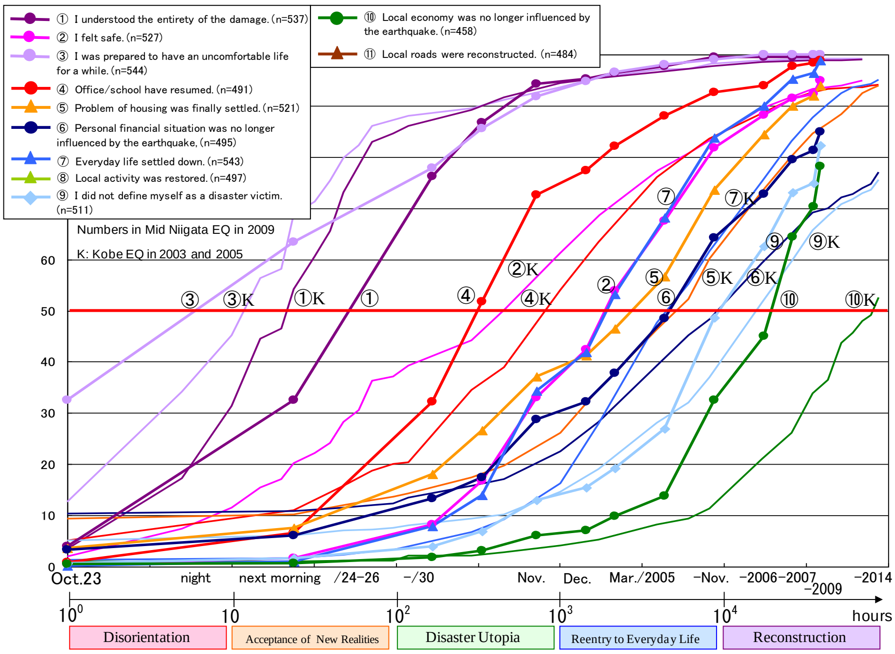

Figure 7. Recovery and reconstruction calendar

(Mid Niigata Survey; fine lines with K show results in Kobe and bold lines in Mid Niigata)

7. Further work

We developed a recovery and reconstruction calendar for measuring overall reconstruction quantitatively for victims and stricken areas, clarifying the disaster process by quantitative examination. We plan to improve the recovery and reconstruction calendar and to study milestones by asking ourselves three questions – how the process can be traced, how the recovery and reconstruction calendar can be used in small- and large-scale social surveys, and how results obtained using the calendar can be applied concretely in disaster response.

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基于地方当局标准防灾人员配置模型的研究

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【摘要】本研究的目的是建立一个标准模型，计算出合理的防灾工作人员规模，以达到有效的灾害管理和高效率的管理。换句话说，它是建立和开发一个地方政府基本防灾工作人员的配额模型，计算标准为当地地方政府的基本防灾工作人员的配额，以实际需要安排防灾工作队伍。研究范围仅限于当地政府工作人员，换句话说，是指负责当地政府自然灾害的防灾工作队伍。基于深入的文本分析，我们以美国减灾系统员工及国家应急管理机构的消防人员为研究对象，通过计算和研究，建立了最小人口变量的最佳防灾工作人员人口计算模型。在这项研究模型分析中，我们使用了国家统计局，地方当局的统计数据，和国家应急管理等各方面的数据。

当适当的减灾工作人口以单独变量被定为韩国的相关防灾工作人口后，显示出了对计算有意义的影响对洪水灾害的发生频率，灾害受害者的人数，灾害预防设施，防灾设施的时间长度，自然灾难恢复的成本，以及预防密度变量有意义的影响。防灾人员计算标准模型可分为内陆山区和沿海平原地区两种类型。

我们预计最后得出的防灾工作人员计算标准模型将作为一个当地政府防灾人员配额的标准配置及客观基础。

【关键词】自然灾害；防灾人员；地方政府；减灾人员计算模；回归模型

RESEARCH ON STANDARD DISASTER PREVENTION WORKFORCE QUOTA CALCULATION MODEL FOR LOCAL AUTHORITIES[15]

15 This paper is based on parts of the research outcome on 『Fire Prevention Workload Calculation Standard Development』 included in the 『2009 R&D Infrastructure Development Project』 conducted by 『Korea Institute of Fire Industry and Technology』.

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The purpose of this research is to establish a standard model that calculates the rational size of prevention workforce in order to support an effective and efficient disaster management administration. When the appropriate prevention workforce was set as the dependent variable to calculate Korea's prevention workforce, the occurrence frequency of flood damage, number of disaster victims, number of disaster prevention facilities, length of disaster prevention facilities, natural disaster recovery cost, and prevention density variables were shown to have meaningful influence on the calculation. The standard model for the prevention workforce calculation was divided into inland mountainous region and coastal plain region.

We anticipate that the finally derived standard prevention workforce calculation model will serve as an objective basis for everyone who needs to calculate the standard prevention workforce quota for basic local authorities.

Keywords

natural disaster, prevention workforce, local authorities, calculation model for disaster prevention workforce quota, regression model

Ⅰ. Introduction

Similar to the case in 1997 when a considerable number of prevention departments experienced severe difficulties due to the lack of workforce when structural adjustments in the public sector workforce resulted in an excessive reduction of the prevention workforce in local authorities, recently there has been a trend of continuous decrease in the prevention workforce quota for local authorities due to the total payroll costs system.

Also, the continuity and professionalism of work is declining remarkably due to frequent changes in the prevention workforce posts. Workforce is being rearranged regardless of the size of local

authority or the balance of regional prevention demand, thus repeating the bitter past of developing a rule of thumb prevention management administration.

In recognition of the above-stated conditions, prevention specialists judge that using a socio-scientific model that derives a rational and efficient prevention workforce quota will contribute to supporting the

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decision-making of chief officers and enhancing the safety and quality of the lives of the local government residents.

Expanding the professional workforce that will take charge of the local disaster management service can be considered as the first step in disaster management (The Ministry of Government Administration and Home Affairs 2003; Jae-Woo Song 2003; The Board of Audit and Inspection of Korea 2003). The difficulty lies in calculating an appropriate number of personnel (Jae-Eun Lee 2006; Kyu-Chool Choi 2009).

Since the establishment of the National Emergency Management Agency, more systematic prevention management policies are being actively enforced, but the profusion of prevention-related work resulting from the changes in the social environment is being oddly matched by the phenomenon of decreasing prevention workforce. Natural disaster management-related research and treatises are at an early theoretical stage globally; they examine the roles and responsibilities of disaster management, and are focused on the methodology for effective disaster response(In-Ho Kang, 2008; Jae-Woo Song, 2003; Ki-Keun Yang et al, 2006;Byeong-Ki Lee et al, 2008; Kirschenbaum, 2004).

Up until now, the majority of advance research related to organizational structure and decision-making in the prevention management area were focused on disaster range, disaster management organizational structure, and disaster management activities, which clearly reveals that the primary response organizations are local governments rather than the Central Government(Yeol-Soo Kim, 2004; Jae-Woo Song, 2003; Ki-Keun Yang,2006; Thomas, 1991). In spite of this, there is still a lack of advance research on determining appropriate standard prevention workforce for local authorities which is the basis to national disaster management.

Recent issues include the implementation of active research and policies in various areas such as the use of risk management technique for disaster reduction, the standardization of disaster management, mutual cooperation between the public and private sectors, national disaster preparedness theory, international disaster reduction activities, the use of prevention facilities and equipment, effective disaster site command system, disaster response theory, countermeasures against natural disaster, problem-solving and decision-making, hazardous material management, climate change response, and international cooperation for disaster management.

A number of research have been conducted by reflecting the opinions of the public employees in basic local authorities on the standard quota by field according to function classification (Eun-Joo Chang, 1999; Kyung-Hun Ko, 2008a, 2008b; Kyung-Hun Ko et al, 2005; Tae-Young Kim, 2005), but prevention researches are generally centered in the U.S and Japan and there is a lack of research on the standard quota for professional workforce for natural disaster, or prevention workforce(Chang-Won Lee et al, 2009). In particular, the right of personnel management was entrusted to the leaders of local authorities through the introduction of the Total Payroll Costs System in January 2007, and since then there has been a rising need to prepare an objective basis to calculate the standard prevention workforce quota appropriate to local governments. In other words, there has been insufficient research to develop an objective standard for the prevention workforce quota, which raises the need for a systematic research.

This paper presents a standard prevention workforce calculation model to determine the appropriate target quota for the prevention workforce of Korea’s basic local authorities. Its purpose is to provide objective basic data for determining a rational number of prevention workforce for local authorities through deducing a standard prevention workforce decision-making regression model by using text analysis about advance research, interviews with prevention employees, and statistical method for regression analysis

The research range was limited to the regional employees in charge of natural disaster work in basic local authorities- in other words, to the appropriate local authorities prevention workforce quota. Disaster type was limited to natural disaster. Also, in advancing the research, the prevention management workforce of the Central Government and state level authority were excluded from the research subject. The purpose of the research is in deducing the standard prevention workforce quota- which indicates the appropriate future prevention workforce quota- according to city/county/district. In other words, it is not a research about the workforce required for prevention but about the standard prevention workforce quota which is the target value for the prevention workforce.

Ⅱ. Reference Research

1. Local Authorities Employees Quota Calculation Techniques

The Local Authorities Employees Quota Calculation Techniques in use include micro method, macro method, and regression analysis(Eun-Joo Chang 1999). First, the micro method- which signifies job analysis- is a method that calculates the quota through the analysis and integration of individual tasks. It is a method of calculating the appropriate number of personnel needed for the execution of office work in local governments; it is a workload calculation method that obtains the number of required personnel by measuring the workload and dividing it into business transaction ability per person.

Second, the macro method is a method that calculates the quota by making comparisons with the number of employees in similar organizations. It is a method that verifies the validity of the allocation standard for the number of employees through a statistical method by comparing the indexes, etc that show the current number of employees, financial status, or administrative demands, etc among common and similar organizations.

Third, the regression analysis has as a premise that there is a mutual relation between the local authorities quota and the administrative demand of the given organization, and expresses the relation between the two as an equation by selecting the variable that has the greatest

interrelation with the number of employees. This technique is a type of macro approach method that uses a deductive model as its premise.

In this research, a regression analysis is implemented in order to derive a regression equation. By expressing the result as a regression equation, it becomes possible to make a mathematical and socio-scientific explanation that can estimate the prevention workforce for each of the local authorities.

2. Investigative Research on the Prevention Workforce Calculation Model by Chang-Won Lee and 5 others

In this research, the research model was modified by applying a grounded theory to derive diverse research variables in order to investigate the calculation model for natural disaster prevention workforce. When the appropriate prevention workforce was set as the dependent variable in the standard prevention workforce calculation, the number of special weather reports, number of refugees, scale of natural disaster damage, area of the local authority, population of the local authority, number of prevention facilities, length of prevention facilities, prevention investment rate, local governor leadership, and natural disaster recovery cost variables were shown to have significant effect.

In regards to calculating the appropriate prevention workforce in future research, since the dependent variable data and prevention workforce vary according to regional characteristic, a dummy variable called region type and an increase in the number of samples will need to be taken into consideration in order to develop a reliable prevention workforce calculation model(Chang-Won Lee et al, 2009).

Ⅲ. Study on the Research Model

3.1 Selection Process of Research Variables

Introduce the independent variables for the research model of the standard prevention workforce quota for basic local authorities by referring to Eun-Joo Chang's Local Public Employee Quota Calculation Model according to Function, Tae-Young Kim's Local Public Employee Standard Quota Model, Chang-Won Lee et al's Investigative Standard Prevention Workforce Calculation Model, The Ministry of Government Administration and Home Affairs' Standard Quota Calculation Method, and the interviews with the US and the National Emergency Management Agency' prevention specialists. Then establish the final research model through the variables selected through as the statistical analysis results.

3.2 Research Model

3.2.1 Development of a Standard Prevention Workforce Quota Research Model

As shown in [Figure 1], the variables that affect the calculation of standard prevention workforce of local authorities are: city/county/district natural disasters, city/county/district prevention management, and city/county/district governor's leadership. There are 4 natural disaster variables that consider the city/county/district regional characteristics: number of special weather reports, frequency of flood damage occurrence, scale of natural disaster damage, and the number of refugees due to natural disaster. The number and length of prevention facilities and the natural disaster recovery cost variables are included in city/county/district prevention management, and as Chang-Won Lee et al.(2009) presented in their investigative research, a dummy variable that reflects the regional characteristic is added. Regional characteristic is classified into East coast region, South coast region, West coast region, inland mountainous region, and inland plain region. Variables included in the city/county/district local authority governor leadership are prevention investment rate and the area of local authority per prevention workforce, or prevention density.

3.2.2 Standard Prevention Workforce Quota Data Collection

In order to develop the standard prevention workforce calculation model, a statistical analysis about the research model needs to be conducted first. Therefore, quantitative data about the 9 variables excluding regional characteristic- which is an independent variable in the research model- is required. As the purpose of the analysis is to develop a model about the prevention employee quota for local authorities, the data on the variables were limited to the data related to the local authorities.

The samples used in the research model were selected from 105 out of the 232 cities/counties/districts in Korea according to the facts stated in the investigative research by Chang-Won Lee et al. Also, as the research samples need to reflect regional characteristics, they were divided into East coast region, South coast region, West coast region, inland mountainous region, and inland plain region according to the opinions collected from the National Emergency Management Agency's prevention management public employees. 11 local authorities- Pohang, Sokcho, etc- were included in the East coast region. 22 local authorities including Goheung, Tongyeong, etc were selected in the South coast region. The South coast region consists of 23 local authorities including Mooan, and Hwasung. 24 local authorities including Bonghwa, and Sancheong were selected as the research samples in the inland mountainous region. Lastly, the inland plain region consists of 25 local authorities including Dalseo-gu Daegu, and Namwon.

The origins of data for independent variables related to 105 local authorities are as follows: The number of special weather reports was collected from the readings from the Meteorolocal Bureau homepage over 3 years since 2006. For the frequency of flood damage occurrence, number of refugees, and the scale of natural disaster damage, the averages of the data collected over 10 years since 1998 from the Annual Disaster Report provided by the National Emergency Management Agency were used. For the data on the area per prevention workforce, the area of local authorities was taken from the National Statistical Office homepage, and the current number of prevention employees in local authorities was collected from the local authorities' homepages. For the number and length of prevention facilities, the 2008 data from the National Emergency Management Agency and the Korea Rural Community Corporation were used. Here, the number

of prevention facilities indicates the sum of the numbers of drainage pump stations, erosion control dam, breakwater, reservoir, pump house, pump station, irrigation reservoir, infiltration gallery, well, etc. Moreover, the length of prevention facilities indicate the sum of the lengths of small rivers(m), irrigation canals(m), and drainage canals(m). Prevention investment rate indicates the local authorities' disaster prevention project costs divided by ordinary tax and uses data collected over 3 years from 2006. Natural disaster recovery cost also uses data collected over 3 years by the National Emergency Management Agency.

3.2.3 Statistical Analysis on the Standard Prevention Workforce Quota Research Model

A research hypothesis is required at the investigative stage for a research model. The first research hypothesis is that all 13 independence variables of the research model affect the standard prevention workforce calculation. In order to determine whether or not to select this research hypothesis, a statistical analysis was conducted on the research variable data related to the 105 local authorities.

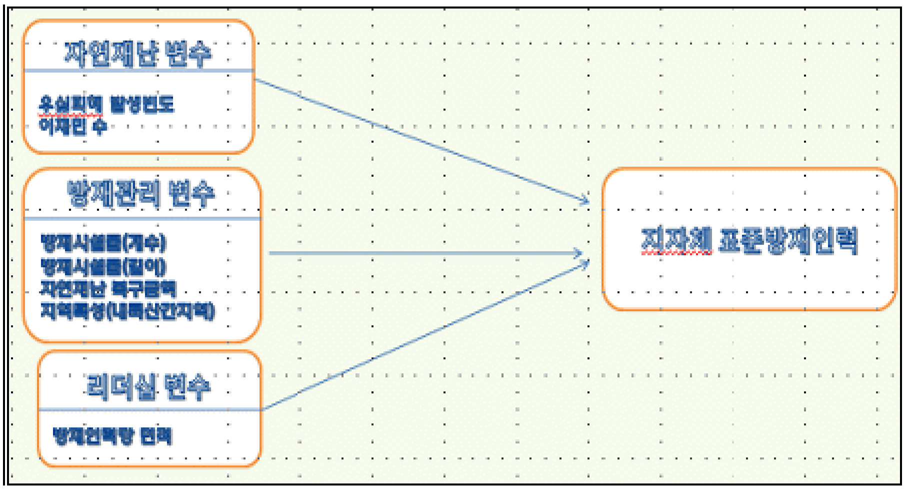
The result of the statistical analysis conducted on the 13 variables related to the 105 local authorities showed that the model had an explanatory power of 43.3% and a significant F-value, and thus the model was selected. However, special weather reports, scale of disaster damage, number of refugees, prevention investment rate, the regional characteristics of the West coast, East coast, and South coast were excluded from 95% of the confidence interval.

Methods for selecting significant variables in the regression analysis include stepwise, forward, and backward elimination methods(Sang-Hyeong Ahn et al, 1993), and the backward elimination method is used at the stage of investigating the research model. The backward elimination method is the method of finally selecting only the meaningful variables by eliminating the meaningless variables one by one.

IV. Corrected Research Model

The corrected research model is shown in [Figure 1]. It is necessary to consider the natural disaster variable measured by the frequency of flood damage occurrence and number of refugees, the prevention management variable that includes the number and length of prevention facilities of the given local authorities, natural disaster recovery cost, and the characteristics of inland mountainous region, and the leadership variable that divides the area of local authority by the prevention workforce to calculate the local authorities standard prevention workforce quota.

[Figure 1] Research Model Corrected for Standard Prevention Workforce Quota Calculation



4.1 Standard Prevention Workforce Quota Regression Analysis

All 7 variables applied to the research model for the calculation of the standard prevention workforce quota affect the calculation of the standard prevention workforce quota. A statistical analysis was conducted in order to prove the selection of this hypothesis by entering data on 7 items related to 105 local authorities, and the result showed that the explanatory power of the model was 44.4%, that the model was significant(0.00), and that all variables were selected in 95% of the confidence intervals(refer to [Table 1]).

For the validity of the research model, the statistical significance level was verified by obtaining the standard error of coefficient. The validity of this research model set the probability of committing type 1 error or 0.05% as the significance level, and all independent variable items were selected at 98.9% confidence interval, which verifies the validity of the model.

[Table 1] Results of Regression Analysis Conducted on the Variables Affecting Standard Prevention Workforce Quota

모 형	비표준화 계수		표준화 계수	t	유의확률
	B	표준오차	베타		
(상수)	8.365	0.377		22.173	0.000
면적/인력	−0.025	0.003	−0.799	−7.745	0.000
복구금액	0.0000000195	0.000	0.261	3.034	0.003
방재시설길이	0.0000013259	0.000	0.225	2.950	0.004
방재시설물갯수	0.002	0.001	0.240	2.641	0.010
이재민수	0.001	0.000	0.197	2.587	0.011
우심피해발생수	0.220	0.053	0.379	4.154	0.000
내륙지역(산악지역)	1.349	0.347	0.316	3.886	0.000
전체	F값(유의확률)=12.873(0.000), R제곱=0.482, 수정된 R제곱 : 0.444				

A regression equation for the standard prevention workforce quota for local authorities was derived based on the results of this regression analysis. The regression formula for the standard prevention workforce quota of inland mountainous region and other regions that takes the regional characteristic into account is shown below. The regression formula is classified into internal mountainous region and coastal plain regions including East coast, South coast, West coast, inland plain region mountainous.

First of all, the regression formula for the standard prevention workforce quota of inland mountainous region= 8.365-0.025 * (prevention density) + 0.0000000195 * (recovery cost) + 0.0000013259 * (length of prevention facilities) + 0.002 * (number of prevention facilities) + 0.001 * (number of refugees) + 0.220 * (number of flood damage occurrences) + 1.349 * (inland mountainous region).

The standard prevention workforce quota of coastal plain region= 8.365-0.025 * (prevention density) + 0.0000000195 * (recovery cost) + 0.0000013259 * (length of prevention facilities) + 0.002 * (number of prevention facilities) + 0.001 * (number of refugees) + 0.220 * (number of flood damage occurrences).

Next, an objective regression formula to obtain the prevention workforce quota of the 232 local city/county/district authorities in Korea was derived. Inserting in the data values of the independent variable items that match each given region into the formula enables the derivation of the prevention workforce quota of the given local authorities.

4.2 Empirical Comparison between Prevention Workforce Quota in Local Authorities and the Standard Prevention Workforce Quota

105 local authorities were classified into West coast, South coast, East coast, inland plain region, and inland mountainous region using the model, and a comparison was made among the estimated values of prevention workforce derived through the regression formula based on the research model of the current prevention workforce quota of the given local authorities, the prevention workforce quota according to the survey conducted on the National Emergency Management Agency’s prevention management representatives, and the standard prevention workforce quota.

A regression formula model with an added compensation coefficient according to regional characteristic was derived only for inland mountainous region. [Table 2] is a comparison chart for the prevention workforce for local authorities in inland mountainous region. The estimated value obtained through the standard prevention workforce calculation model for inland mountainous region is 243, and shows that the current prevention workforce at 199 is in lack of 44 persons.

[Table 2] Empirical Comparison Status of Local Authorities in Inland Mountainous Region

Local Authority	Realistically Required Prevention Workforce (Survey)	Current Prevention Workforce	Estimated Values of Prevention Workforce according to Regression Model	Required Workforce to Prepare for the Current Prevention Workforce
Bonghwa	11	10	10	0
Andong	11	9	10	1
Mungyeong	9	7	10	3
Changnyeong	10	9	11	2
Sancheong	10	7	12	5

[Table 3] is a comparison chart for the prevention workforce in East coast, which is a coastal plain region. The estimated value obtained through the standard prevention workforce calculation model for East coast is 107, and shows that the current prevention workforce at 75 is in lack of 32 persons. Similarly, the West coast is shown to be in lack of 34 persons, South coast of 48 persons, and inland plain region of 39 persons.

[Table 3] Empirical Comparison Status of the Local Authorities in the East coast Region

Local Authority	Realistically Required Prevention Workforce (Survey)	Current Prevention Workforce	Estimated Values of Prevention Workforce according to Regression Model	Required Workforce to Prepare for the Current Prevention Workforce
Pohang	11	8	9	1
Wuljin	9	6	8	2
Youngduk	11	9	11	2
Sokcho	9	7	10	3
Samcheok	11	8	10	2

The analysis of the workforce calculation obtained through the standard prevention workforce calculation model showed that there was an overall lack of prevention workforce by an average of 39.4 persons(refer to [Table 4]). The allocation basis of the current prevention workforce in local authorities was shown to differ according to the local authorities, and the result of investigation on realistically needed prevention force showed that there the values were similar to the prevention workforce obtained through the regression model.

[Table 4] Calculation Results of Prevention Workforce by Type of Region

Region	Realistically Required Prevention Workforce (Survey)	Current Prevention Workforce	Estimated Values of Prevention Workforce according to Regression Model	Required Workforce to Prepare for the Current Prevention Workforce
Inland region(moutainous)	243	199	243	44
West coast region	207	171	205	34
South coast region	207	158	206	48
East coast region	104	75	107	32
Inland region(plain)	223	182	221	39
Average Workforce	196.8	157	196.4	39.4

In particular, the result of comparing the current prevention workforce quota and standard prevention workforce quota showed that the values varied by a minimum 1~2 persons, and by a maximum of 4~5 persons. However, observing the result from the aspect that the values signify future prevention workforce quota, the number of personnel needs to be higher than the current prevention workforce quota, and it is expected that a more objective comparison with other local authorities will enable a more rational decision-making on the matter.

V. Conclusion

Most of the research conducted in Korea in the natural disaster prevention management field deal with the range of disaster, disaster management organizational structure, disaster management activities, response of climate change, and international cooperation for disaster management. Also, with the insistence on the importance and necessity of prevention workforce by many researchers, a reasonable amount of research results have been obtained in calculating the number of public employees and standard fire service workforce, but the research on calculating the appropriate prevention workforce for natural disasters still remains at the level of investigative research.

In this research, we aimed to contribute to establishing an objective standard through a standard model in calculating Korea's prevention workforce by presenting a model to calculate the appropriate prevention workforce based on related references and interviews with specialists. When the appropriate prevention workforce was set as a dependent variable in calculating Korea's prevention workforce, variables including the frequency of flood damage occurrence, number of refugees, number of prevention facilities, length of prevention facilities, natural disaster recovery cost, and prevention density were shown to have significant effect on the calculation result. Also, the standard model was classified into inland mountainous region and coastal plain region in order to be used in the prevention workforce calculation.

The standard model provides information that enable governors of local authorities to make flexible decisions on prevention workforce according to regional characteristic. It presents data that provide an explanatory basis for arranging appropriate prevention workforce according to the regional characteristic of local authorities and prevention environment, and can be used in making more systematic and scientific arrangements for prevention workforce. In particular, the exclusion of the most basic socio-demographical variables selected in existing social science research such as population and area- in other words, population density- and the use of the prevention density variable expressed as the local authorities' prevention workforce and area, provided an occasion to confirm the special quality of prevention workforce, and brought academic results in which new socio-scientific variables such as prevention density were derived.

The current lack of diverse socio-scientific research to calculate appropriate prevention workforce must be quickly ameliorated. We anticipate that the limitations up to now in trying to explain the necessity of prevention workforce only from disaster recovery-centered perspective will be overcome and that there will be continuous research conducted to present rational and scientific explanatory indexes.

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将减少灾害风险纳入中国发展议程主流的框架探索

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【摘要】中国是世界上最容易遭受灾害的国家之一，随之而来的是巨大的经济损失和不可估量的间接损害。本篇论文介绍了在中国政府决策过程特点的背景下，将减少灾害风险 (Disaster Risk Reduction, DRR)纳入到中国发展议程主流的框架探索，并分析了在此过程中将面临的各种机遇和挑战。在 DRR 纳入主流的初始阶段为了兼顾灵活性和可操作性，本论文提出了“1 +3 + N”的结构框架作为项目切入点。这个框架包括建设综合政策推进平台；三个强化战略方向：面向社区建设，面向社会参与，参与政策相关过程；在三个战略方向的基础上选择合适的合作伙伴开展可行的示范项目。最后论文指出在将 DRR 纳入中国发展议程主流的同时，相应的制度变迁需要更加深入的研究和实践。

【关键词】减少灾害风险(DRR) ； 发展议程； 纳入主流；框架；中国

EXPLORING FRAMEWORK FOR MAINSTREAMING DISASTER RISK REDUCTION INTO CHINA’S DEVELOPMENT AGENDA

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Key words

DRR, development agenda, mainstreaming, framework, China

Abstract

China is one of the most disaster-prone countries in the world with huge economic losses and incalculable

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indirect economic damages. This paper introduces a Disaster Risk Reduction (DRR) mainstreaming into development agenda framework in China under the specific characteristics of Chinese government policy making process, including the identifications of challenges and opportunities need to be addressed. "1 +3 + N" structural framing is chose as entry points which is flexible and operational to enhance mainstreaming DRR in the initialization phase in China. This framework including building of platform for comprehensive policy promotion; the three orientations enhancement: community oriented, social participation oriented, and policy-making process oriented; potential demonstration projects launch collaborated with selected appropriate partners according to the three orientations enhancement. In conclusion, this paper calls for further studies and practices on institutional change accompanied with the process that DRR mainstreaming into development agenda simultaneously in China.

1. Introduction

China is one of the most disaster-prone countries in the world, which recurrently struck by a variety of natural disasters, including floods, droughts, cyclones, sandstorms, snowstorms as well as earthquakes in history. Besides natural disasters, man-made disasters including public health emergencies, industrial accidents and social security events cause more than 200,000 deaths and 2 million injuries each year, with more than 600 billion RMB economic losses and incalculable damages[1].

Since the launch of reform and opening policy in 1979, China's GDP has grown rapidly with an average of 9.8 percent per annum. Although the achievements in terms of economic growth and poverty alleviation achieved, vulnerability remains one of the obviously obstacles in a sustainable development context especially for the poor people and potential recurrent poor people in China, those who are not able to cope with economic, health, environmental, social, and natural risks.

The government of China has made great effort in large-scale engineering-based disaster prevention infrastructure construction in past three decades. In the meantime, the limitations of this single approach in fighting against disaster risk are being revealed with the increasing frequency, scale and impact to the society of experienced various disasters. To address such limitations, the 'One Plan Three Systems' strategy has been set up as the basis of a new comprehensive and scientific emergency management system. 'One Plan' refers to contingency plan. 'Three systems' respectively refer to structure, law and mechanism. As a political consultative mechanism, the National Committee for Disaster Reduction (NCDR) consisting of 34 ministries and central government bodies was established in 2000, accordingly. NCDR mainly focus on the post-disaster respond and relief, and the pre-disaster risk reduction and preparedness is rarely to be fully integrated due to low DRR awareness, lack of operational framework and action, and also the restrictions of departmentalized mandates and resource allocation. In the recent decade, a number of large international organizations and many countries have received the general consensus on mainstreaming DRR into development agenda to respond to and manage the disasters and potential risks. It is important for China to share international experience on pre-disaster preparedness and risk reduction, and adopt such trends and localize DRR with multi-sector and multi-disciplinary efforts to minimize losses.

Therefore, the paper will firstly study the international experiences and operational framework concerning mainstreaming DRR into development agenda, and the focus would be put on the characteristics of China's policy making process and consequently the exploring framework of mainstreaming DRR into China's development policy. The last part will be the discussions and possible study areas of DRR framework in future. Despite all those working on mainstreaming DRR into development agenda, the experience sharing is expected by authors and hopefully it could contribute to the more wide and deep studies and applications of DRR both in China and in the whole world-wide.

2. Literature Review and International Experiences

The study related to the development of DRR framework has started in the early 2000s, and most of the efforts are focused on methodology-based and natural science-based framework. There were several distinguished projects focusing on DRR framework. A project called "Indicators for Disaster Risk Management" financed by The Inter-American Development Bank was implemented by the Instituto de Estudios Ambientales to measure key elements of countries' vulnerability to natural hazard events and the performance of different disaster risk management policies and tools of Latin America in 2003. United Nation's International Strategy for Disaster Reduction (UN-ISDR) initiated an online conference and presented a first attempt on an operational DRR mainstreaming framework with indicators and benchmarks to capture progress that contributes to reduction of those identified risks in 2003, too. Although the goals of two projects have slight difference, both of them are national-level oriented and full of indicators in the building of the DRR framework. The ProVention Consortium with financial support from the UK government's Department for International Development launched a project titled "Measuring Mitigation: Methodologies for assessing natural hazard risk and the net benefits of mitigation" with the emphases on application at the project level rather than the national level. Thomas Mitchell argued that the DRR Mainstreaming Framework should be flexible enough to be modified which should be locally derived from four sections: politics and legislation, policy, knowledge, and practice with 20 indicators and benchmarks[2]. In the initiatives of mainstreaming DRR in China, each of those four sectors should be involved, too.

Those projects boosted research on DRR framework and paved the way for the further application research, however, there are still gaps to serve as a guide for action at the respective levels of policy making. At the same time, exploration and practice on mainstreaming DRR into development related issues has began in worldwide. In Myanmar, a detailed Action Plan for Disaster Risk Reduction is undergoing through the workshop and forum participated by many stakeholders [4]. This national action plan addresses the policy, institutional arrangements and further institutional development at different levels which contributes to the integration of DRR into policy making decision. In terms of sectoral development issues, Philippines had identified Agriculture, Education, Health, Housing, Urban Planning and Infrastructure and Financial Services as priority sectors to initiate mainstreaming disaster risk reduction [5]. Road Sector had implemented this new mainstreaming DRR policy by assessing the possible impact on project of natural disasters or other hazards in the planning phases with multi stakeholders' collaboration, it means that the appropriate risk reduction measures can be included in the project. Philippines's experience suggested an enhanced natural hazard/impact assessment component should be included, and also the existing system for monitoring road needs and the capacity of staff to assess should be enhanced. A training course was provided by Asian Disaster Preparedness Center with support provided by AusAID to build capacities and enhance understanding among the participants on mainstreaming DRR in the national and sector development process in Asia in 2010 [3]. Such training courses are expected to promote the related policy and strategy directly by sharing the experience by the government and sectoral officers.

In a word, the methodology-based DRR framework has developed many indicators for the assessment and identification disaster risk as the starting point in the early 2000s, on the other hand, the explorations and practices have beginning currently both in national and sub-nation, sectoral levels. The involvement of multi-stakeholders, international experience sharing through training course, collaboration with national, local, and sectoral institutions, hazard/impact assessment involvement in project implementation are the common consensus achieved yet in mainstreaming DRR into development agenda.

3. Situation analysis of Policy making process in China

According to Thomas Mitchell statement that politics, legislation, and policy should be considered in DRR mainstreaming framework. Hence, it is necessary to analyze the specific characteristics of policy making process in China, since Chinese government system is quite different with most of the other countries in the world, such as dual leadership at local government, inconsistent between planning cycle and government officer duration, preference for demonstration project and experience dissemination and so on. All those specific characteristics require special strategy for DRR practice localization in China based on international experiences. Therefore, a deep understanding of China's public policy making process and the corresponding challenges and opportunities under such government system will pave the way for mainstreaming DRR in to China's development policy and the application in China.

1. Characteristics of policy making process in China

To analyze the characteristics of policy making process in China, it is instructive to examine the history of China's efforts and strategies coping with poverty alleviation (as shown in table 1), climate change (as shown in table 2), and disaster reduction and emergency management (as shown in table 3).

Table 1: The development of China's poverty alleviation strategy

Time	Policies and strategies
1986	poverty alleviation was specified in national development strategy, and poverty alleviation policy was shifted from traditional relief-oriented to development-oriented.
1993	The establishment of State Council Leading Group for Poverty Alleviation and Development, subsistence security system for urban residents was launched in Shanghai.
1994	National Seven-Year Priority Poverty Alleviation Program was launched.
1997	Regulations on the establishment of the national subsistence security system for urban residents, pilot study began to be implemented in rural areas.
1999	Subsistence security ordinance for urban residents was issued.
2007	Establishment a nationwide subsistence security system in rural areas.

Table 2: China's history of coping with climate change

Time	Policies and strategies
1990	The Chinese government set up special institutions to deal with climate change issues.
2007	The National Leading Committee on Climate Change, headed by the Chinese premier, was established. “China’s National Climate Change Program” was published.
2008	The number of member units for the National Leading Committee on Climate Change increased from 18 to 20, China's Provincial Climate Change Program project was launched.
2009	16 provinces, municipalities and autonomous regions basically set up the leading committee on climate change at provincial and municipal level, some provinces had already announced programs to response to climate change.

Table 3: China's history of response to disaster

Time	Policies and strategies
1950	The Central Disaster Relief Committee headed by vice premier of government administration council Dong Biwu was established.
1978	Many institutions were set up at the national and State Council level, including the National Committee for Disaster Reduction, the State Flood Control and Drought Relief Headquarters, the State Council Earthquake Relief Headquarters, the State Forest Fire Prevention Headquarters, the National Nuclear Emergency Coordinating Committee and the National Disaster Relief Overall Coordination and so on.
2003	Regulations on preparedness for and response to emergent public health hazards was published, the Emergency Rescue Plan Group under the Office of the State Council was established.
2005	National master plan for responding to public emergencies was issued.
2006	State Department Office of Emergency Management was set up.
2007	Emergency response law of the People's Republic of China was promulgated.

These observations reveals the special policies and strategies implemented by Chinese government, some key characteristics are summarized in follows:

1. The leading and ruling position of Chinese Communist Party (CCP), and combination system of legislative and authority

CCP is the single ruling party, and Chinese People's Congress is the country's legislature and authority. Hence, mainstreaming DRR should attach importance to policy consensus within the CCP and the internal consistency at the administrative and legislative levels in order to realize policy impacts.

2. All-departments are unanimous consent for the policy and specific department is fully responsible for implementation.

There are nearly 50 committees, ministries and subordinate agencies under the State Council. The division of powers between the various departments is relatively clear and avoiding overlapping. Coordinating body of procedure is the special institution for inter-departments issues regarding to important multi-sectoral policy making, such as NCDR. Such coordinating body is lower than the entity ministries in terms of organization, and an entity ministry is responsible for transactional work accordingly. NCDR is located in the Ministry of Civil Affairs which in charge of the disaster reduction policy implementation.

3. Dual leadership at local government.

In China, different levels of local government departments are always faced with how to coordinate between horizontal government and vertical higher level inter-departmental relations. Currently, China's main approach is the combination of horizontal and vertical operational guidance.

4. Government performance evaluation based on quantitative indicators.

Overall, there is no uniform, clear and systematic performance evaluation system in Chinese government. Generally the evaluation and promotion of officials are believed to be closely related to performance evaluation based on quantitative indicators. Accordingly, various levels of government officers emphasis on quantifiable achievements.

5. Inconsistent between government planning cycle and government officer duration.

Chinese all-level governments attach importance to traditional long-term planning, especially five-year plan and ten-year plan which not only provide an important indicator of long-term development, but also the most important basis for policies and actions in all areas of China. On the other hand, many government/department leaders' duration is inconsistent with the planning cycle, which may cause short-term actions and many other problems.

6. Policy making process is relatively closed.

With the deepening of reform and open policy, different social subjects' participation in policy making is being enhanced. However, generally speaking, the Chinese government's policy process is relatively closed, and tends to exclude the non-governmental subjects' participation. This feature will be more prominent in DRR and climate change adaptation areas from time to time.

7. Preference for demonstration project and experience dissemination.

Chinese government prefer to adopt demonstration project due to the great success in the model of pilot extension in rural during the initial reform and opening period. For the central government departments, pilot extension is an effective strategy to delay decision-making and to avoid the policy debate. For local government, pilot extension is a good opportunity to obtain a discretionary space and additional resources.

To analyze the characteristics mentioned above, we come to a conclusion that various factors challenge the mainstream of DRR in to strategy of national development. Careful consideration for department partner and the synergy between the various departments, and the relationship between local governments and functional departments need to meet to realize policy impacts. Moreover, from the perspective of practice and application, the impacts on government performance evaluation system of DRR should be addressed, especially for the inconsistent between planning cycle and officer duration. Demonstration project and experience dissemination might be the most feasible entry points for DRR mainstreaming in avoiding the closure policy making orientation.

3.2 Challenges

To better exploring mainstreaming DRR into development agenda framework in China, a deeper analysis for the challenges and opportunities is shown in the following parts, which would contribute to the strategic thinking for framework building. The challenges need to be addressed for China to meet the targets on mainstreaming DRR framework building are:

1. Inter-sector collaboration barriers cause difficulties.
2. Sector fragmentation will also lead to many difficulties.
3. DRR has not yet completed with many uncertainties.
4. Short-term and long-term conflict of interest would affect the relevant departments’ and officials’ attitudes of DRR.
5. The inertia of traditional engineering-based disaster prevention policy constraints the approval of DRR among relevant departments.
6. Lack of direct leadership by the central department and the local authority department increasing the difficulty of mainstreaming DRR.
7. Challenge posed by the top-down and relatively closed policy making process approach of Chinese government.

3.3 Opportunities

Although there are many challenges mentioned above, opportunities remain as follows:

1. China is a disaster-prone, high population density, vulnerable eco-environment, severely climate change affected and unbalanced developing country, consequently the ideal country for the application of DRR.
2. As the development goal proposed by Chinese government, “The harmonious society” consistent with DRR intrinsically.
3. As a new policy issue, climate change adaption can provide more policy space for the mainstreaming DRR.
4. The social safety net will become the major poverty alleviation strategy, therefore DRR will be put more emphasis.
5. Relatively independent of local government in policy making process provides a larger space for

DRR demonstration project in local level.

6. DRR can give effective support in construction and amelioration of the emergency management system.
7. Encouraging the social participation is involved in DRR, which provide the appropriate entry points for DRR.
8. China, as the most influential developing country in the world, the success of DRR could achieve better results of demonstration and dissemination.

9. DRR implementation strategies in China

According to the above analysis of characteristics, challenges and opportunities for mainstreaming DRR into China's development agenda, the following implementation strategies are suggested to adopt in current situation.

1. conception transition ---policy community

Strengthen publicity, education, training and policy research to build consensus basis for the implementation of risk management in China.

2. Practical exploration---innovation model

Enhance the innovative and comprehensive demonstration projects launch, and explore the localization of risk management implementation in China.

3. Lessons Learned—Evaluation Indicators

Improve lessons learned from the pilot projects, and construct evaluation system of risk management implementation in China.

4. Strategic Adjustment--Institutional Change

Promote the constructions of law, regulation and policy system in terms of mainstreaming risk management into development agenda.

5. DRR Mainstreaming framework in China

we could choose "1 +3 + N" structural framing as entry points. Here, "1" means the building of platform for comprehensive policy promotion; "3" means the three orientations enhancement: community oriented, social participation oriented, and policy-making process oriented; "N" means potential demonstration projects launch collaborated with selected appropriate partners according to the three orientations enhancement.

6. "1"--comprehensive policy promotion platform

it is essential to build comprehensive policy promotion platform with partners. This platform facilitates the comprehensive arrangement of demonstration projects in terms of project management, project evaluation and policy dissemination and popularization.

7. "3"--three enhanced strategic orientations

1. **community oriented**

From the perspective of DRR characteristics and existing China's organizational structure of disaster reduction and emergency management, it is the most proper way to conduct pilot projects in communities. Communities are the base unit of social activities, and also faced with various risks and the most vulnerable social unit, comparatively. Currently DRR related researches and studies center on community level. At the same time, community is just the kind of organization between government and society, and it is much easier to promote DRR in community. For those reasons, community oriented is a significant entry point for mainstreaming DRR.

2. **Social participation oriented**

Strategy development and implementation recommended in this paper is based on the establishment of a broad partnership so as to influence policy making process, the cooperation with multi-sector is indispensable. The involvement of social participation in policy making process is becoming the major trend simultaneously. Social participation oriented strategy coheres with this trend and the idea of DRR itself.

3. **Policy-making process oriented**

Mainstreaming DRR into China development agenda is a long-term task, rather than simply influence the introduction of some specific policy or law. In addition, the participation in relevant policy making process is an approach of developing and expanding DRR influence, which is the core of implementation strategies suggested in this paper.

4. "N"--- demonstration projects launch

In order to coordinate with the three strategic enhancements, it is necessary to launch a series of demonstration projects with partners.

In general, The framework for mainstreaming DRR into development agenda is shown in figure 1, including the analysis of Chinese government policy making process characteristics, challenges, opportunities, and the entry points. The development of such framework will be an operational guideline for the forthcoming effort both in policy making and practice application in China.

Figure 2 framework for mainstreaming DRR into China's development agenda

5. Discussion

The framework for mainstreaming DRR into China's development agenda is flexible and operational under the complicated and quick changing of social, economic and natural environment currently. Comprehensive policy promotion platform is supposed to include those who have similar perception, policy insights and appeals, such as government entities, academic institutions, consulting agencies, NGOs, enterprises, and other stakeholders. It is expected to be an far-reaching starting strategy for the awareness consensus and implementation of DRR in China as a think tank institution. In the meantime, Launch innovative and comprehensive demonstration projects in all possible aspects for the approval of DRR conception and framework. Moreover, the knowledge learning and experience sharing in pilot projects should also be supported to boost the interaction between such policy experiments and national decision-making departments.

However, we should also noticed that there is no generally accepted policy advocacy in fields of DRR among government and the public in China. How to strengthen publicity, education, training and policy research to build consensus basis for the implementation of DRR framework remains one of the obstacles in China right now. Although the framework we have designed for the mainstreaming DRR, the initialization phase requires the approval and appropreciate pilot project from the specific sectors of government.

Many works remain to be finished in the following studies and practices. In order to improve lessons learned from the pilot projects, develop evaluation system of DRR implementation is necessary.we should develop relevant policy evaluation system with quantitative analysis methods both in mainstreaming DRR into policy agenda and policy experiments. Such policy evaluation system is expected to launch the corresponding tools and policy measurement evaluation, and government performance assessment.

The core objects of mainstreaming DRR are to influence the corresponding strategic decisions of government, to incorporate DRR into national macro-development strategies, and to be adopted as an important policy approach in fields of disaster reduction, emergency management, poverty alleviation, and climate change adaption. Institutional change is one of most significant challenges need to be addresses in the whole process of mainstreaming DRR in China. How dose such strategic adjustment match along with the changes of the relevant system, mechanism, law and regulation simultaneously should also be further studied and practiced.

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