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DEVELOPING A HUMAN-CENTERED DESIGN MODEL OF DISASTER MANAGEMENT

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ABSTRACT

The occurrence of natural disasters include landslides are part of the human life that can not be suspected. Knowledge and education regarding the disasters is absolutely required by the people in the disaster areas to achieve a safe, responsive and resilient state in disaster management. Based on the fact that Semarang city has a quite high potential of landslides occurrence in its almost area, human factors should be deeply considered since human is the most influenced part of the system if the disaster occurs and human also suspected as one of the cause of disaster occurance. Empowerment of human as individual and community is an important point to achieve a successful of disaster management program. Community preparedness in disaster management can be mapped through a questionnaire-based interviews to obtain behavior of community in landslides preventing, facing and coping. So this study aims at developing model of a human-centered design in disaster management especially in landslide cases in Semarang city using human factor toolkits. This also aims at obtaining a detailed phase of disaster management with focusing on community awareness both of in cognitively and physically states.

Keywords: human factor toolkits, disaster management, landslide areas, semarang city, human-centered design

1. INTRODUCTION

The occurance of natural disasters are part of the human life that can not be suspected. Knowledge and education regarding natural disasters is absolutely required by the people in the disaster areas to achieve a safe, responsive and resilient in disaster management.

As the capital of Central Java, Semarang city is rapidly expanding as marked by the development in all fields that are currently running. This development must be balanced with a more specific handling of the disaster control to protect the assets and development results that have been achieved and to provide a sense of security from disasters (either before/pre- or during disaster/emergency response) and post-disaster.

Based on the fact that Semarang city has a quite high potencial of landslildes occurrence in its almost area [1], human factors have to be considered since human is the most influenced party of the system if the disaster occurs and human also suspected as one of the cause of disaster occurance. Empowerment of human as individual and community is an important point to achieve a successful of disaster management program.

Human factors as one of interdisciplinary science always consider people and their interaction with the technology and environment. The application of a human-centered philosophy to the design and operation in disaster management provide lot of profits regarding its vast activities and technical systems. Human factors and ergonomics can be used to prevent and decrease death and injury from similar events in the future. Since disaster management is a complex decision-making process that aiming at establishment of a model framework within specific communities, concept of ergonomics science should be applied in every phase and action in disaster management system. It aiming at reducing vulnerability to hazard, and organize themselves to respond to disaster and recover from them.

Some studies analyse how the human factors and ergonomics play roles in disaster management based on the importance of information management. Horberry et al. [2] studied the role of human factors in mining emergency management related collection and management of the information during underground coal mining emergencies from a human-centred perspective. They also focus on decision making deficiencies in incident management teams and the final one examines organisational issues related to mining control rooms during emergencies. Curnin and Owen [3] studied information mining in Australian emergency management system. In this study, the perceived information requirements of senior strategic level

emergency management personnel and how they obtain this information were investigated. Another study by Santos et al. [4] examined medical emergency dynamics in disaster-prone countries. This study considered implication of medical device design.

Based on the related studies in human factors related disaster management, there was a few study concerning human factors regarding the cognitive and physical readiness and awareness of the resident to prevent, face and cope the disaster. Human factors toolkits is a toolkit to support the consideration of human factors in site inspections, accident investigations and assessment of documentation of safety reports. Based on definition of human factors by Health and Safety Executive/HSE [5], it is mentioned that "Human factors refer to environmental, organizational and job factors, and human and individual characteristics, whics influence behavior at work in a way which can affect health and safety". So with regard to this definition, human factors can be used to examine the behavior of human related to their environment, organization and job factors. Human acts and omissions can play a role in the initiation, mitigation, escalation and recovery phases of an incident. The scope of what HSE means by human factors includes organisational systems and is considerably broader than traditional views of human factors/ergonomics. Human factors can, and should be included within a good safety management systemand so can be examined in a similar way to any other risk control system.

In disaster management system, this concept will be very usefull to analyze in detail the cognitive and physical behavior of the resident in disasater-prone area to prevent, face and cope the events.

The improvement of community (resident) awareness is performed by understanding and mapping of community behavior towards disaster prevention, equipments and commitment establishment from the community to the policy of the government of Semarang city.

Previous study by Sriyono [6] discussed about the pattern of human relationship to their environment within landslide case in Semarang regency. It was stated that stone mining activity and forest disruption by fields and other land usage have an impact on the increasing of landslides potential in Semarang city.

Policies and programs from the Government of Semarang for this case of disaster is still focused on government institutions as the party that are serving the emergency response and post-disaster. The community, especially residents in disaster-prone areas require adequate guidance and education regarding the environmental conditions. Mapping of physical and mental awareness of citizens to the possibility of natural disasters continued to the increasing of citizen knowledge about the condition of the disaster-prone areas through the recommendations and dissemination of disaster management based on the results of the mapping. Community preparedness in disaster management can be mapped through a questionnaire-based interviews to obtain behavior of community in landslides preventing, facing and coping. Based on this backgrounds, this study aims at developing model of a human-centered design in disaster management especially in landslide cases in Semarang city using human factor toolkits. This aims at obtaining a detailed phase of disaster management with focusing on community awareness both of in cognitively and physically states.

2. LITERATURE REVIEW

2.1 Landslides in Semarang and its Causes

Disaster is a serious disruption in a community that occurs as a result of catasthrophe or human activities. Disasters require a coordinated response by the State and other entities to help communities recover from the disorder. Serious disorder include the loss of lives, disease or injury to persons, and / or loss of or damage to property and / or environment that extends / severe [7].

Semarang city is one of the major cities that is unique in terms of morphology. The city is divided into two contrasting morphology within a very close distance. Down town area in the northern part directly adjacent to the beach, while the hills in the southern part has very short distance. City area under the flood-prone, while hilly areas prone to landslides. Seven of the 16 districts in the city of Semarang have prone points of landslides. They are Manyaran, Gunungpati, Gajahmungkur, Tembalang, Ngaliyan, Mijen, and Tugu. Contour of the land in the districts is hilly and fracture areas with unstable soil structure.

Skepton and Hutchinson [8] stated that landslides or land movements is defined as the movement of the land down the slope by the masses of soil and rocks composer the slope and/or through disruption of the stability of soil or rocks composer its the slope. Many factors such as geological and hydrological conditions, topography, climate, and weather changes can affect the stability of the slope and causes landslides. The movement of land mass occurs when the three circumstances are fulfilled, namely:

1. Slope quite steep.
2. There is a sliding plane below the waterteight soil surface.

There is enough water (from rain) in the ground over impermeable layers, so that the soil is water-saturated.

Subheadings are flush left, in 10 point type and bold and upper and lower case as shown. There should be one line space both before and after this level of heading, as shown in the subheading for this paragraph.

2.2 Disaster Management

Disaster management is defined as the setting of the effect management that potentially harmfull of an event, including, for example, the setting of mitigation,

prevention, preparedness, respond and recover from a disaster. Research on the disaster can be understood broadly as a systematic investigation of the situation before and after the disaster and relevant issues of disaster management relevant [7].

Strategic of management is recommended based on Office of the Queensland Parliamentary Counsel [7], including:

1. Identification, support and arrangement of resources priority
2. Understanding the lessons identified for developing policies, regulate the allocation of research, planning and resources.
3. Establishing a web that contains the latest information and an up-to-date information that can be accessed by stakeholders to share information on disaster management.
4. Transferring knowledge towards practice action through the plan review and system of procedural and processes.
5. Allowing research access
6. Establishing formal relationships with researchers and research institutions to gain knowledge of disaster management into effective policy and practice.
7. Recognizing and incorporating the principles of intellectual property in all research activities.
8. Using an evidence-based method for measuring, monitoring and improving community relations and education.

Disaster management should be well-planned based on 4 phases, namely prevention, preparation, response and recovery. The first phase and prioritized in this study is prevention that performed through development of human-centered design concept for disaster management focused on residents who live in the vulnerable zone.

2.3 Human Factors Toolkits

The key document in understanding HSE's approach to human factors are reducing errors and influencing behavior. As mentioned before, the definition of human factors including three interrelated aspects that must be considered: the job, the individual and the organization [5]. The detail of each aspect can be seen in Figure-1.

There are some important points in Human Factor Toolkits that should be considered in developing a human-oriented disasater management system. Since this research is a preliminary study, then the analysis is classified in Level 1 Topic in human factors toolkit with the core topic is identifying human failure.

The first step is organizing a pre-visit documentation including discussion with the managers and operator in the site to understand the environment. The next one is categorizing human error/failure and error management. In this phase, the identification of incident causes and error pattern will be taken into account. Identification is conducted for each aspect of human factors (individual, job and organization) and classification of the human error is performed.

The third step is analysis of human reliability analysis (HRA) both in qualitative and quantitative mode. Event/Failure Tree Analysis can be used to identify the potential human failures and optimise the factors that may influence human performance as well as to estimate the likelihood of such failures occurring.

The next step is determining the Performance Influencing Factors (PIFs). Performance Influencing Factors (PIFs) are the characteristics of people, tasks and organizations that influence human performance and therefore the likelihood of human failure. The topic of human factors toolkits covered in this study is categorized as general guidance and adapted into disaster management system in landslide areas.

Figure-1. Three interrelated aspects in human factors [5].

3. DEVELOPMENT OF MODEL

A peliminary model is developed to map human behavior of the community in landslide areas both in physically and cognitively framework. The basic model for this study is inspector toolkit that aims at managing human factors in major accident hazard [5]. This concept is adapted into a method that utilized to analyze human behavior in a disaster area (in this study is in landslide areas in Semarang).

The fundamental objective of this model is to reduce errors and control the behavior of the community in the landslides disaster management. This objective can be achieved by designing a systematic model containing detail phase to map each scenario and possibility of human error that may be occured in landslides area. By doing so, severe and mild loses (life and economics) can be reduced through behavioral mapping and prioritization of the required actions in disaster

management.

Mapping of human behavior when facing a disaster can be conducted based on 5 phase as seen in Fig. 2. In detail, phases of the mapping are:

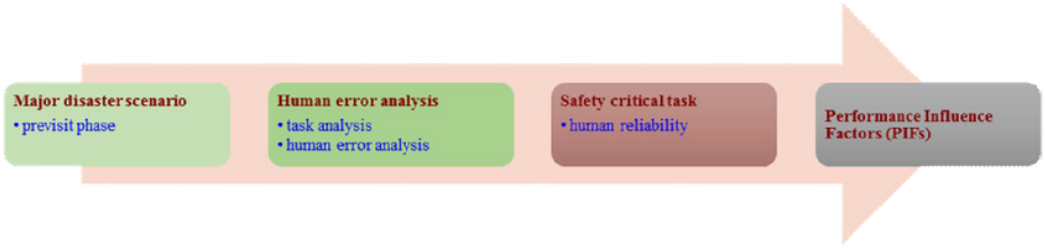

Figure-2. Work Frame of Human Factor Mapping (adapted from UK Human Factors Inspectors Toolkit) [5].

1. Major disaster scenario
   In this phase, identification of disaster scenario that have occured must be recorded and evaluated based on the measurement of risk. This phase is similarized as the phase of pre-visit in the Human Factors Toolkit.
2. Human error analysis
   There are two important analyses in this phase: task analysis and human error analysis. Task analysis includes identification of stakeholder roles in disaster occurance and mapping of responsibility of each party at all levels of concerned organization. It the kind of task, where and when the task should be performed. Analysis of human error is performed by evaluation of potential errors that may occur in mitigation activity and in the occurance of previous disaster.
3. Safety critical tasks
   This phase includes a further analysis of human failure. It is an evaluation of human reliability based on qualitative analysis.
4. Performance Influencing Factors (PIF)

This phase considers potensial factors that increase or decrease human errors. For example, identification of human error based on respons to alarm and work planning and supervising.

Based on the analysis of human factors and system classification, human error can be specified as *decision error, skill-based error* dan *perceptual error.* The type of error influences the mapping result of awareness and community behavior during disaster management [9].

4. PRELIMINARY IMPLEMENTATION OF THE MODEL

4.1 Research areas

Research areas are determined by preliminary studies, covering 20 location that represent 3 level of vulnerability in landslide areas in Semarang city (high vulnerability, vulnerable, quite vulnerable).

4.2 Responden

A total of 107 respondents are participating in this study distributed in 20 locations of landslide areas in Semarang city. The number of respondent for each area is variated depends on the result of proportion calculation between the number of populations and wide of the research area. The minimum number for each research location is 5 respondents.

4.3 Methods

Method research in this study is starting by designing a major disaster scenario in landslide cases. It is continued with design of human error classification by comparing the expected and observed behavior of the resident in landslide areas. A safety critical task then is performed and finalized by the last step that is an analysis of PIF based on factor analysis using statistical investigation.

4.4 Major Disaster Scenario

In this phase, identification of disaster scenario that ever occurs is taken into account and evaluated based on scenario measurement. Based on the data from BPDP Semarang [10], there were 8 occurances of landslides in Semarang city during 2013. This number was increased become 23 events in 2014. Until May 2015, there were 9 occurances of landslides in Semarang city. This prove that there is a high risk and potential of landslides in Semarang city. Therefore the residence in this area should be awared and have a basic knowledge of the landslide to avoid a bigger loss. The expected scenario of landslide incidents are:

a. Before the landslide occurs
   - Recognize the signs of landslides (continuous and heavy rain, the color of the river water becomes turbid, water seepage or ground cracks is appearing, the sound of thunder or there is a small avalanches).

- Identification of vulnerable groups and open, high and safe spaces nearby.
- Identify/mark the place that can become a safe evacuation (yard, field, etc.).
- Agree on an early warning system (the sound of sirens, the sound of the gong, hearing the landing from the officer, note the evacuation path).
- Stay away from prone areas.

b. During the landslide
- Do not panic.
- Secure treasures and important documents.
- Running and refuge to a safe place.
- Immediately call for help.
- Evacuate if conditions require.
- Pay attention and listen to the information from the reliable sources and act quickly in accordance with the appeal.

c. After the landslide occurs
- Perform first aid to yourself.
- Stay away from places affected by the landslides.
- Act quickly followed the appeals from authorized stakeholders.
- Return to the home if conditions permit.

4.5 Human Error Analysis

The role of stakeholders in the occurance of landslides is identified based on the presence or absence of the organization implementation of the landslide disaster management from the central or local government as well as whether the institutions or organizations that exist have been carrying out their functions properly.

The activeness of citizens in disaster management or the level of citizen participation in implementing organizations will also affect the level of knowledge and safety of citizens.

Task analysis is the analysis of actions to be taken by the relevant authorities when a disaster occurs. In other words, this analysis is used to determine (1) what action that should be and was taken by the competent executing unit, (2) if the unit is already implementing its functions correctly, and (3) whether government policies have been implemented.

Government policies include the education preparedness, evacuation criteria for before and after disasters, the warning systems and the emergency response plans.

Analysis of human error is made by the evaluation of potential errors that may occur. By doing this analysis, the wrong action that was taken by the residents in mitigation activities and when a disaster occurs in the previous period can be recorded and evaluated. There are two criteria of expected action, they are: Criterion 1 (protect yourself, stay away from heavy objects, helping people, and contacting relatives when the disaster occurred) and Criterion 2 (save yourself both in saving himself out of the house or go to the open field, followed by evacuation activites to a safe place, and leave the landslide areas).

4.6 Safety Critical Task

Safety critical task is conducted to evaluate the buman reliability during the occurance of landslides. Human reliability is analyzed using event-tree analysis (ETA). ETA defines and compares the events either have or have not happened or components have or have not failed. By doing so, the consequences arising from the failure or undesired events can be taken into account.

4.7 Performance Influence Factors (PIFs)

PIF considers the factors that could potentially increase or decrease human error. In the analysis of PIF operation, it will be identified the level of human error mistakes e.g. decision errors, skill-based errors, or perceptual error.

The meaning of decision error is the fault of the respondents in the decision making of disaster mitigation. Skill-based errors is a situation where a false actions in disaster management are taken, while perceptual error is the failure of the community in capturing the signs of a problem existance.

Those three kinds of error can be caused by some factors, such as the absence of mobilization of resources and lack of family preparedness plan.

4.8 Data Mining

Primer data in this study is data of community awareness towards disaster management. Instrument in this phase is a closed questionnaire and in-depth interview because the responden have variated levels of education background and disaster knowledge. The expected data are assessment of community behavior in preventing, facing and coping landslides. Data mining is conducted by distribution of the questionnaire with direct supervision from the researcher team to obtain a valid and qualified answer. Responden of this study are residents living in the zones with minimum level of quite vulnerability.

Questionnaire material include residents' knowledge and understanding to landslide mitigation, situation of emergency response and disaster management.

In detail, the questionnaire contents can be seen in Table-1.

Table-1. Questionnaire material for mapping of resident behavior in landslide areas

Nr.	Topic	Detail contents
1	Understanding of local situation	Map of landslide area, basic geological condition, etc.
2	Knowledge of disaster prevention	Location of landslide, safety and emergency aid equipements, evacuation route and location of

		evacuation, etc.
3	Experience when facing landslides	Condition of physical, mental and environment situation, etc.
4	Awareness facing landslide disaster	Role of disaster education, socialization of disasater management, resident participation, etc.

The in-depth interview is performed integrated with questionnaire distribution by designing a structured interview content. Interview material includes some questions about experiences and strategy in disaster management in located area.

5. CONCLUSION AND FURTHER STUDY

Based on the result of the recent study, it can be concluded that human factor toolkits can be implemented in disaster management. It is a very useful tool to design a human-centered disaster management in landslides area. There are 4 detailed phase of the developed model. They are identification of major disaster scenario, human error analysis, safety critical analysis, and performance influencing factors.

The further study should be focused on practical implementation of the model. Data mining that comparing expected model and observed behavior of the community should be taken into account. A detail implementation also can be prepared, for example detail of awareness action and the stake holders such as social agency, Indonesian National Army (Tentara Nasional Indonesia/TNI), Geophysical and Meteorological Agency (Bada Meteorologi dan Geofisika/BMG), Search and Rescue (SAR), Police, Hospitals, Indonesian Red Cross (Palang Merah Indoensia/PMI), Non-Profit Organization, mass media and Community Group of Disaster Management (Kelompok Masyarakat Penanggulangan Bencana/KMPB). The next level of covered topic based on human factors toolkit should be also considered to obtain some detail of disaster management, e.g. design of emergency response, safety culture (as the common topic) and organizatonal change (as a specific topic).

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