

Pilot Implementation of Human-Centered Model in Disaster Management

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Received: January 2017/ Accepted: July 2017 / Published online: December 2017
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Abstract Semarang has a high potential of landslides occurrences in its almost area that should be noted by the stakeholders. Consider this fact, human as the part of the system should be used as a center of the disaster management system to reduce the risk caused by the disaster. An adapted model of human factor toolkits is developed to represent a specific phase of human-centered disaster management. This model presents four phases including major disaster scenario, human error analysis, safety critical task and performance influence factors (PIFs). As the preliminary implementation, this study takes the pilot implementation of each phase of the model to examine the reliability of the concept in the landslide cases, especially in Semarang city. The result shows that there is quite a high deviation between expected and observed behavior of the community and the government institution regarding the awareness states of the system.

Key words: Human-Centered Disaster Management; Landslide Areas; Semarang City; Implementation

Abstrak Semarang memiliki potensi tinggi kejadian tanah longsor di hampir seluruh wilayah yang perlu diperhatikan oleh instansi terkait. Mempertimbangkan fakta ini, manusia sebagai bagian dari sistem harus dijadikan pusat sistem manajemen bencana untuk mengurangi risiko diakibatkan bencana. Adaptasi model perlengkapan faktor manusia dibuat untuk merepresentasikan fase spesifik dari manajemen bencana berpusat manusia. Model ini memberikan empat fase yaitu skenario bencana, analisis kesalahan manusia, beban keamanan kritis dan faktor pengaruh performa (PIFs). Sebagai implementasi awal, penelitian ini mengambil pelaksanaan pilot setiap fase dari model untuk menguji keandalan konsep dalam kasus longsor, terutama di Kota Semarang. Hasil penelitian menunjukkan bahwa ada deviasi yang cukup tinggi antara yang diharapkan dan observasi perilaku masyarakat dan lembaga pemerintah mengenai sistem kesadaran negara.

Kata kunci : Manajemen Bencana Berpusat Manusia, Wilayah Longsor, Kota Semarang, Implementasi

1. Introduction

Based on the fact that Semarang city has a quite high potential of landslides occurrence in its almost area [Purba, 2014], 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 causes of a disaster occurrence. As a capital of Central Java Province, Semarang city is rapidly developing in all of the fields. These developments lead to increasing numbers of building as well as expanding as marked by the development in all fields that are currently running. They 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.

Recently, studies of disaster management are mostly concerned about supply chain management of logistic systems [Hale and Moberg, 2005; Hagani and Afshar, 2009; Cozzolino, 2012; Hong et al., 2015] and technical issues of disaster from geological point of view specifically in Semarang city [Purba, 2012; Sriyono, 2012]. Some specific studies regarding human factors are conducted to improve the preparedness of special population such as children [Short et al., 2013] and elderly [Lachlan et al., 2013]. Investigation of the government roles [Molk, 2013], how to cope with disaster trauma [Kar, 2013] and risk management in disaster [Gonzales, 2006, Freeman et al., 2003] are also a highly researched topic in disaster management.

The focus of the policies and programs of the Government of Semarang City for the case of disaster is the establishment of government institutions that serve the emergency responses and post-disaster action. The community, especially residents in disaster-prone areas that require adequate guidance and education regarding the environmental conditions only regarded after the disaster occurs. It means the awareness and preparedness of the community in the disaster area

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are not prioritized by the government until this study started. Besides, the human is the part of the system that should be role as a center of the disaster management system to reduce the risk caused by the disaster.

Mapping of physical and mental awareness of citizens to the possibility of natural disasters aims at examining the community knowledge about the condition of the disaster-prone areas. The results of mapping will be used as recommendations and dissemination of disaster management. Community preparedness in disaster management can be mapped through questionnaire-based interviews to obtain behavior of community in landslides preventing, facing and coping using the concept of human factors.

Human factors is an interdisciplinary science that considers the interaction between human and the technology and environment. The application of a human-centered philosophy into design and operation in disaster management provide many 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 is aiming at the establishment of a model framework within specific communities, the concept of ergonomics science should be applied in every phase and action in disaster management system. It is aiming at reducing vulnerability to hazard, and organize themselves to respond to disaster and recover from them.

Some studies analyze the role of human factors and ergonomics in disaster management based on the importance of information management, e.g., Horberry et al. [2013] 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-centered perspective. They also focus on decision-making deficiencies in incident management teams, and the final one examines organizational issues related to mining control rooms during emergencies. Curnin and Owen [2013] 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. [2013] examined medical emergency dynamics in disaster-prone countries. This study considered the implication of medical device design. Kruchten et al. [2007] developed a human-centered conceptual model of a disaster affecting critical infrastructures including four packages in the model: (1) communication and coordination, (2) regions, cells, people, businesses, wellness, (3) infrastructures and (4) events, disaster. Specifically concerned with landslide areas in Semarang, a study by Sriyono [2012] discussed 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.

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. The intervention of ergonomic cognitive in the disaster management should be deeply considered as a key mental aspect of applied disaster management success. With this cognitive factor, the human cognition during the critical phase is not impaired by stress or emotional distress of the decision-makers and collaborating agents [Coelho, 2013].

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 the definition of human factors by Health and Safety Executive/HSE [2005], it is mentioned that "Human factors refer to environmental, organizational and job factors, and human and individual characteristics, which influence behavior at work in a way which can affect health and safety". So concerning 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 implement a role in the initiation, mitigation, escalation and recovery phases of an incident. The scope of what HSE means by human factors includes organizational systems and is considerably broader than traditional views of human factors/ergonomics. Human factors consider a good safety management system and thus can be assessed in a similar way to different risk control system.

In disaster management system, this concept will be very useful to analyze in detail the cognitive and physical behavior of the resident in the disaster-prone area to prevent, face and cope the events. The improvement of the community (resident) awareness is performed by understanding and mapping of community behavior towards disaster prevention, equipment and commitment establishment from the community to the policy of the government of Semarang city.

Based on this backgrounds, this study aims at developing a model of a human-centered design in disaster management especially in landslide cases in Semarang city using human factor toolkits. Moreover, the goal implements a detailed phase of disaster management with focusing on community awareness both of in cognitively and physically states.

2. The Methods

This study uses an adapted Human Factors Toolkits to build a human-centered model of disaster

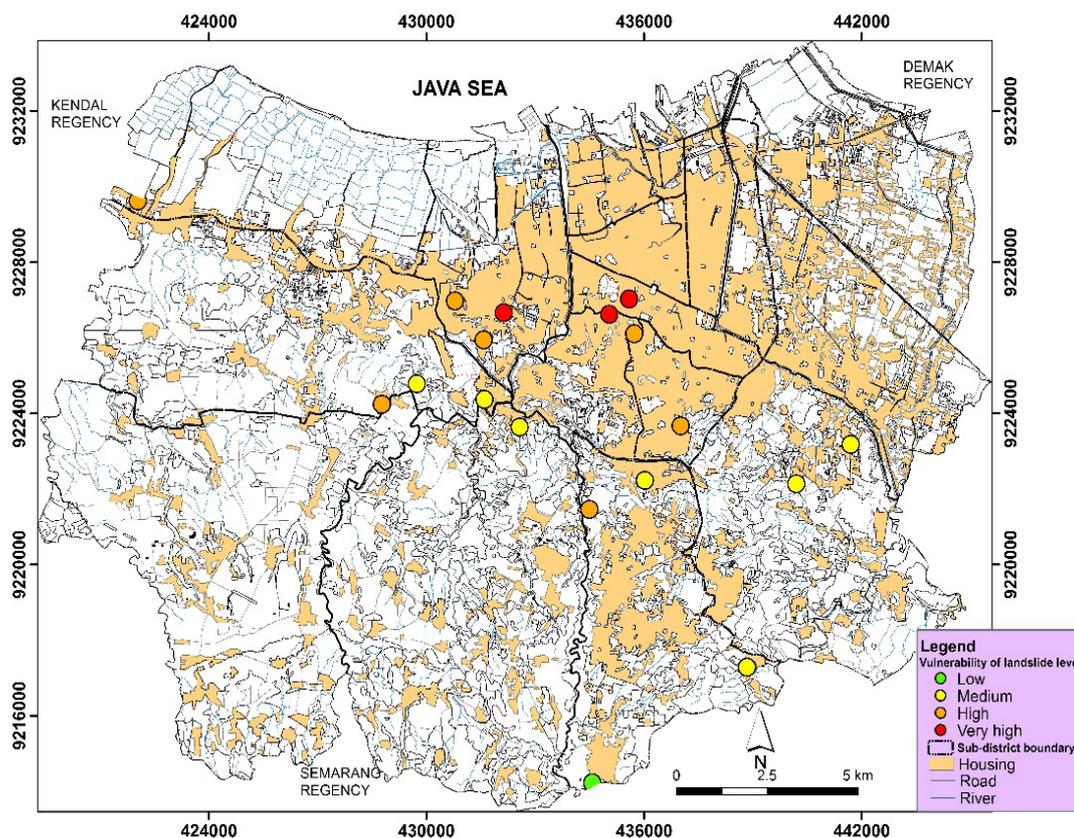


Figure 1. Study area and questionnaire survey (20 points area) based on the vulnerability level of landslide.

management in landslide areas as explained in detail in the previous study [Putranto and Susanto, 2016]. Primer data in this study is data of community awareness towards disaster management. The instrument in this phase is a closed questionnaire and in-depth interview because the respondents have varied levels of education background and disaster knowledge. The expected data are an assessment of community behavior in preventing, facing and coping landslides. Data mining is conducted by the distribution of the questionnaire with direct supervision from the researcher team to obtain a valid and qualified answer. Respondents of this study are residents living in the zones with a minimum level of quite a vulnerability.

There is a total of 107 respondents are participating in this study. The ages of the respondents vary from 17 to 56 years old. Seventy-four percent (74%) respondents have a range from 17-40 years old. The others are 41-56 years old. The respondents are distributed in 20 locations of landslide areas in Semarang city. These locations are determined by a preliminary study and represented 4 level of vulnerability in landslide areas in Semarang city (very high vulnerable, high vulnerable, medium vulnerable, and low vulnerable) as seen in Figure 1. The number of respondent for each area is varied on the result of proportion calculation between the numbers of

populations and wide of the research area (Nazir, 2003). The minimum number for each research location is five respondents. Questionnaire material includes residents' knowledge and understanding to landslide mitigation, the situation of emergency response and disaster management.

3. Result and Discussion

Based on the adapted model of the human-centered design of disaster management [Putranto and Susanto, 2016], there are four phases of the human factor mapping. They are major disaster scenario, human error analysis, safety critical task and performance influence factors (PIFs). Each phase is implemented specifically for the landslide case study.

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 BMKG Semarang [2015], there were eight occurrences of landslides in Semarang city during 2013. This number was increased become 23 events in 2014. Until May 2015, there were nine occurrences of landslides in Semarang city. It proves that there are a high risk and potential of landslides in Semarang city. Therefore the

residence in this area should be aware 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

- Understand about the environment condition includes prone level of the area to landslide occurrences.
- 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 avalanche).
- 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).

b. During the landslide occurrences

- 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 by the appeal.

c. After the landslide occurs

- Perform first aid in person.
- Stay away from places affected by the landslides.
- Act quickly followed the appeals from authorized stakeholders.
- Return to the home if conditions permit.

Based on the results of the study, some real actions deviate from the expected actions. The observed behavior is:

a. Before the landslide occurs

The most significant finding is that only about 42% respondents understand about the environmental disaster including a landslide in their areas. It means about 58% respondents have limitation aware that the area they live is a prone area to landslides due to unprecedented landslides in this region. Thus, the community have a safe perception in this region.

This condition leads to a priority of landslide socialization for the community in some landslide areas. The socialization and basic education of landslide occurrence should be conducted as soon as possible to improve the awareness state of the community in Sendang Mulyo, Pudak Payung, Mugasari, Randusari, Mangkang Kulon, Baban Kerep, Kedung Pane, and Kalipancur areas.

Based on the respondents knowledge, it also results that the primary causes of the landslide are heavy rain (80%), steep slopes (11%), less solid ground (4%), less dense rock (3%), and unknown (3%).

The recently warning systems in Semarang city is the traditional system (gong, door to door) (77%), local agreements such as the existence of guard post and the officer who oversees the village and provide a warning for citizens in case of natural disasters (12%), and provision of information and warnings after the disaster by churches/ mosques/other worship places (4%) and unknown (7%).

b. During the landslide occurrences

From the results of the questionnaire from 107 respondents, 78% experienced a panic response, and 22% did not panic when the disaster occurs. 22% of respondents who did not panic had attended some preparedness training of natural disaster, so that when the landslide occurred they do not panic and can save many things when a disaster occurs. The mental readiness of residents in areas prone to landslides is still very low. Only residents in the area Pleburan, and Sukorejo that looks ready to face the possibility of landslides.

c. After the landslide occurs

It is frequently accomplished after a disaster occurred is a refuge activity for victims of the landslide occurrences. Based on research that has been conducted, a casualty evacuation during emergency conditions is in houses that are not affected such as the nearest relative's house or a neighbour's house. Detail of destination place for each research area during the disaster can be seen in Figure 2.

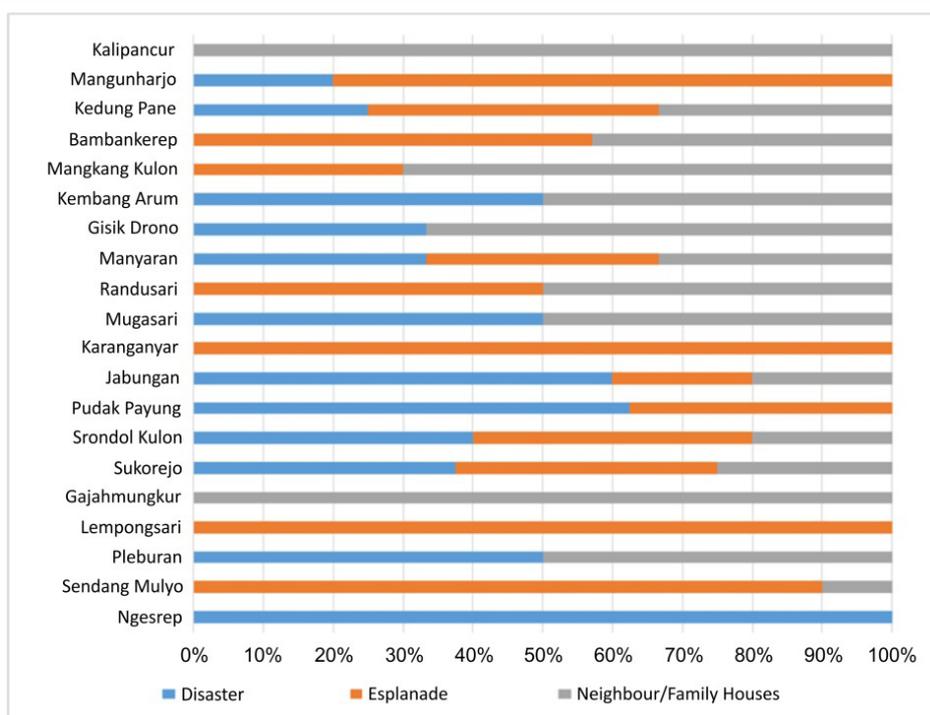


Figure 2. Destination place of the landslide is refugee in Semarang city.

Human Error Analysis

1) Task Analysis

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

The example of the task analysis in disaster management in certain landslide areas can be seen in Figure 3. The policy of local government such as emergency planning, the warning system for landslides, evacuation criteria before the disaster occurs and awareness education has not achieved satisfactory results as seen in Figure 4.

As seen in Figure 4, only Sukorejo area has been implemented the policy to start the evacuation before and after the landslide occurs

as well as prepare the warning system. Many residents in other areas do not actively involved or even aware of the existence of the policy and the executing unit. There are also many unusable facilities in these areas that should be notified to the residents.

2) Human Error Analysis

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 activities to a safe place, and leave the landslide areas). The detailed action for each research point can be seen in Figure 5. It is shown that the community in the majority of the landslide areas act dangerous behaviours when the landslide occurs. Only the community in Pudak Payung, Srondol Kulon, Sukorejo, Sendang Mulyo and Ngesrep that act properly with safety point above 50%, while 100% community in Lempongsari and Pleburan already fulfil the expected reaction when a landslide occurs.

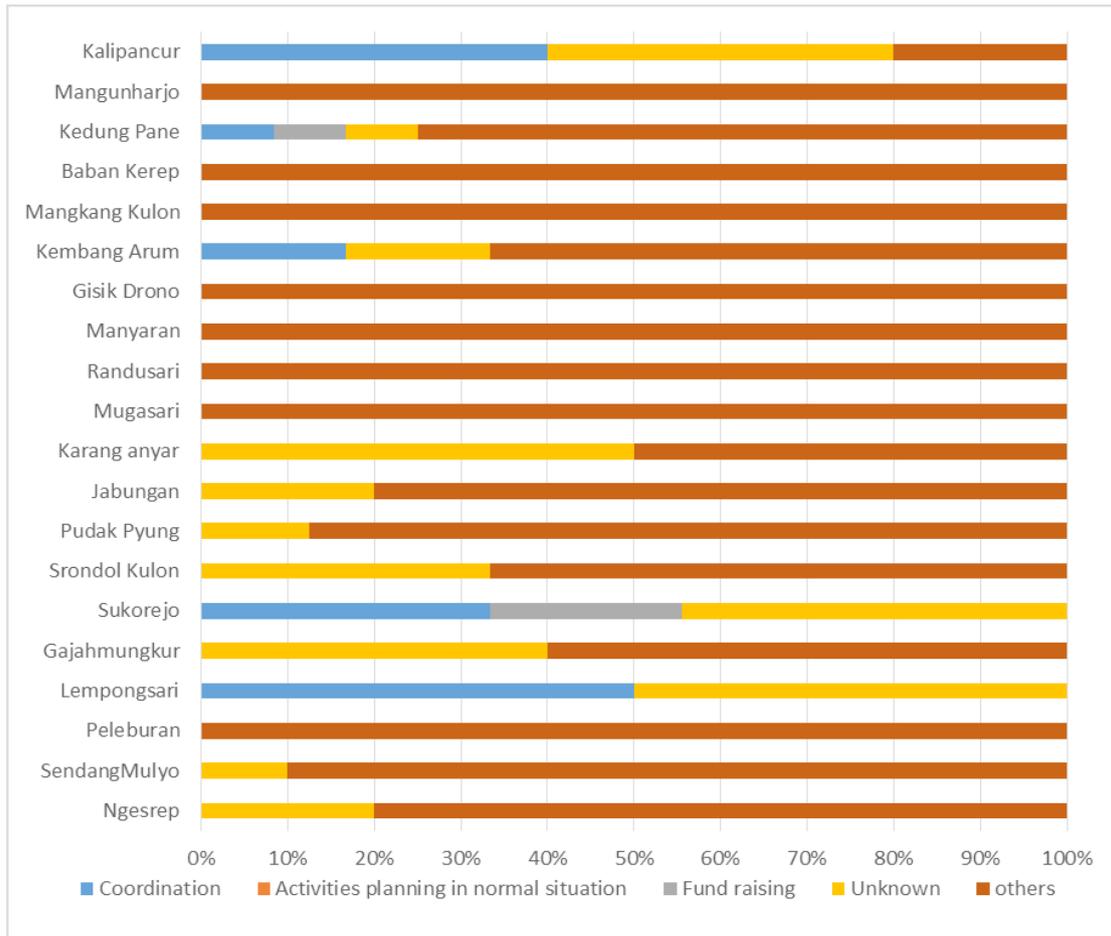


Figure 3. Task analysis of executing unit.

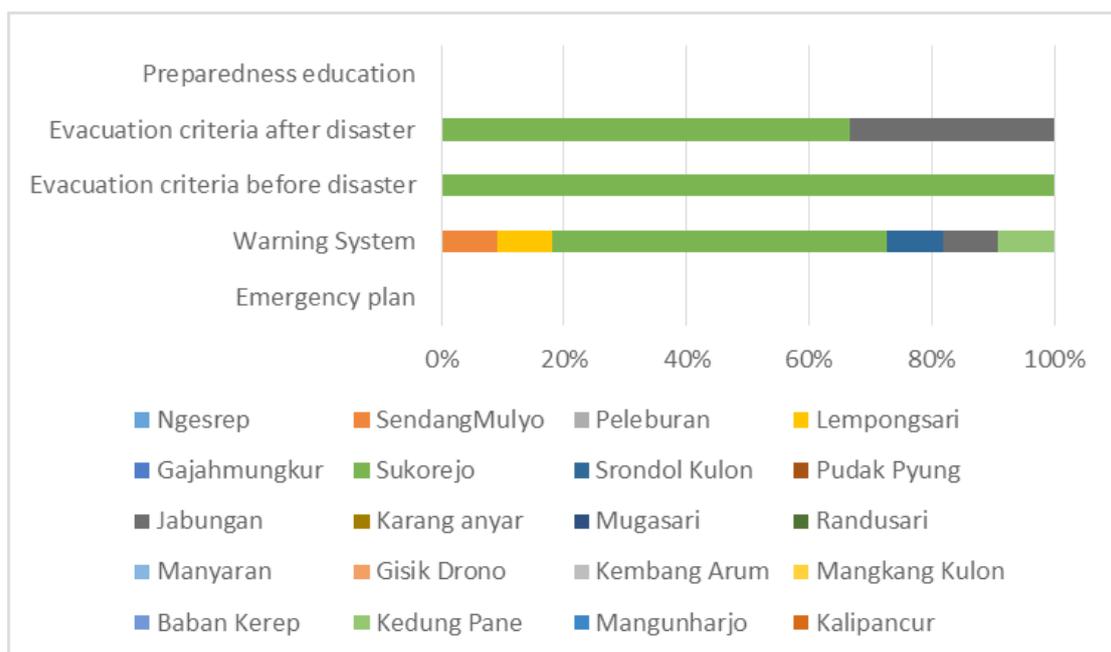


Figure 4. Implementation of local government policy.

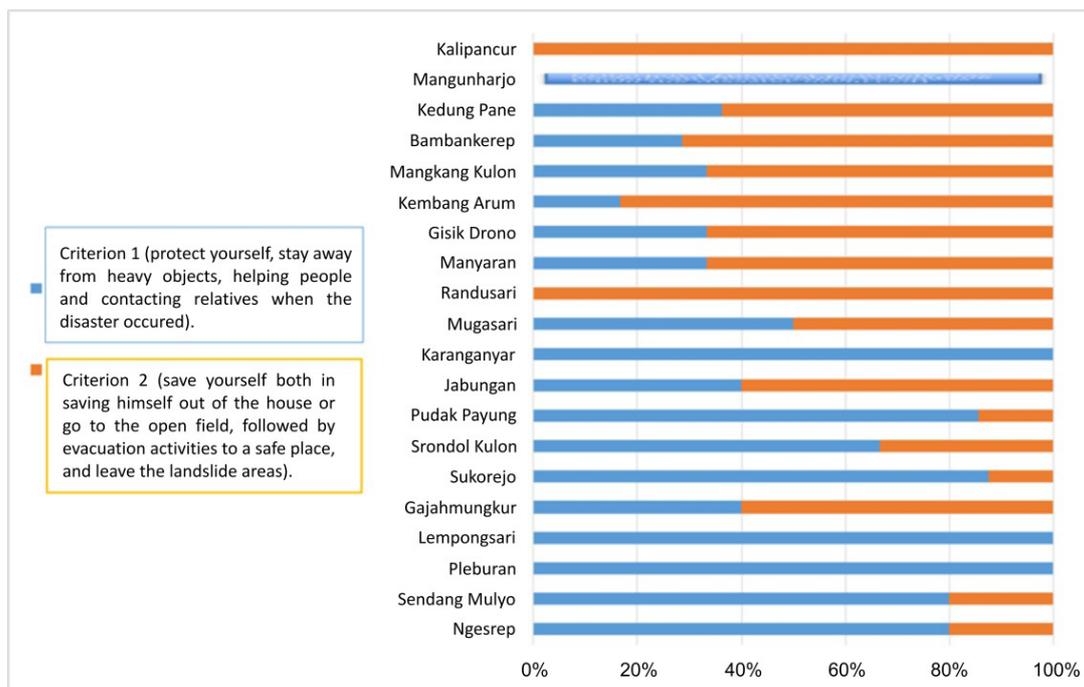


Figure 5. Community actions when the landslide occurs.

Human Reliability Analysis

Human reliability is identified based on the different type of human error; they are decision error, skill-based error, and perceptual error. Decision error is a respondent error regarding decision-making phase in disaster mitigation. The skill-based error is a situation in which there is an error regarding taken action in disaster

mitigation, while the perceptual error is community failure to interpret the signs of a problem. These errors are possibly caused by several factors such as the lack of resources mobilisation (Figure 6), preparedness planning for the family (Figure 7) and knowledge of disaster map (Figure 8).

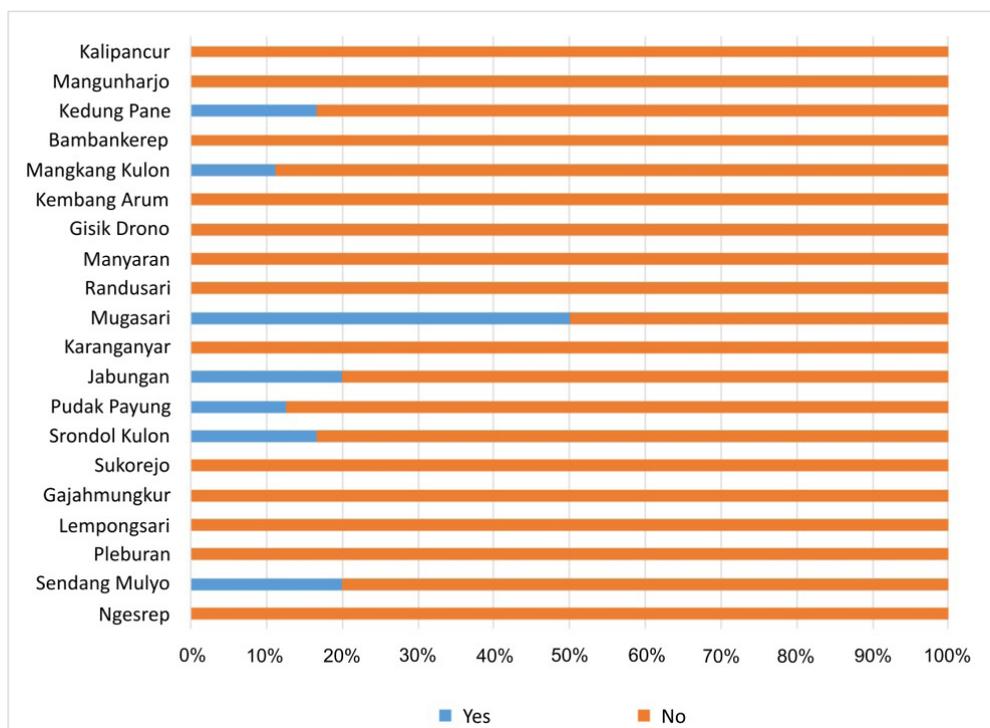


Figure 6. Resources mobilization.

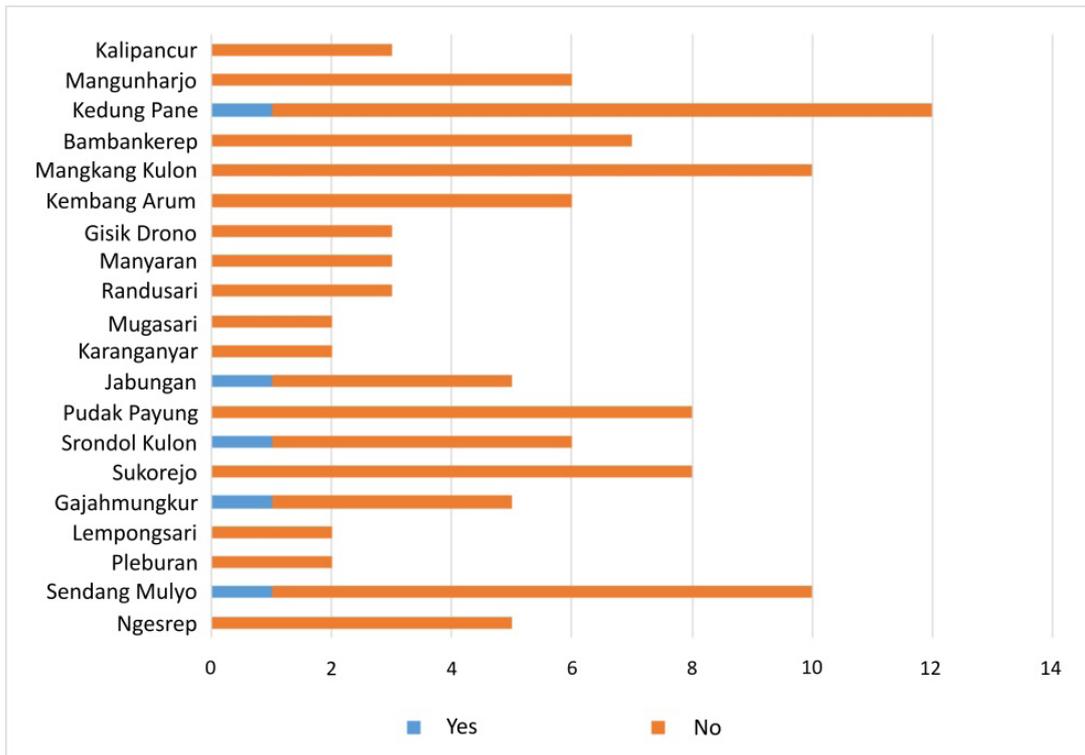


Figure 7. Preparedness planning for the family.

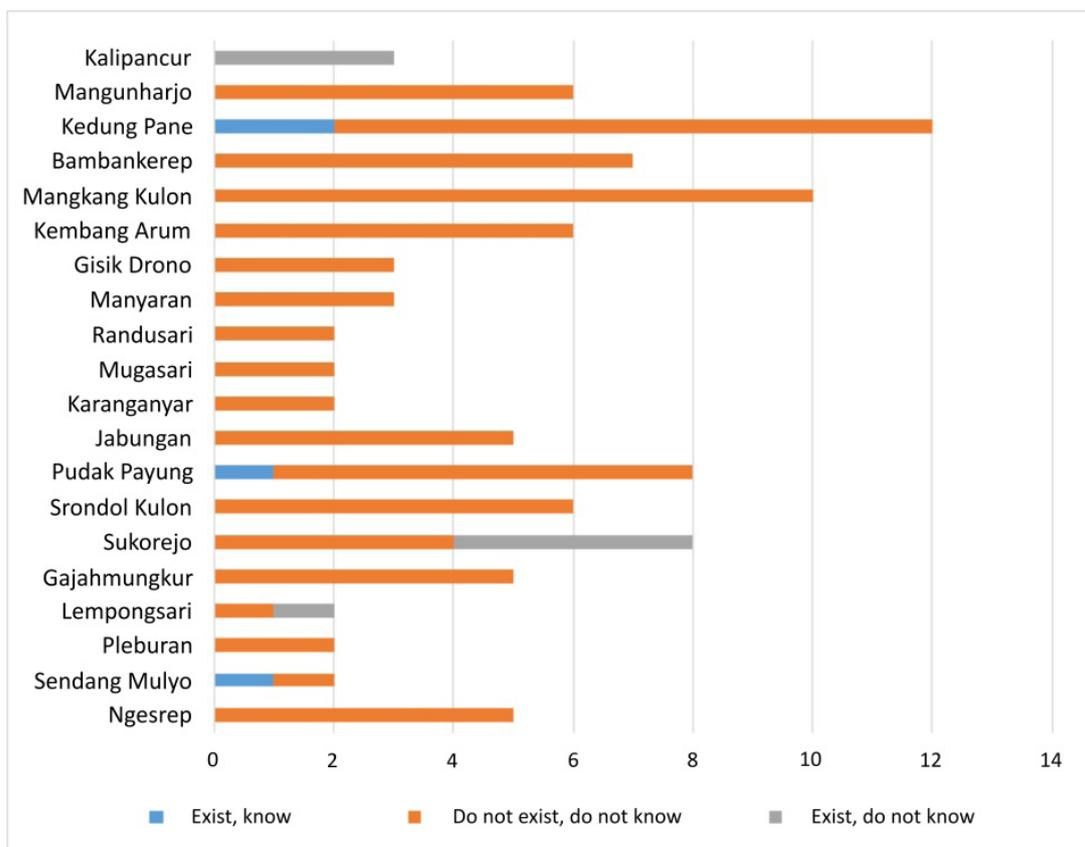


Figure 8. Knowledge of disaster map.

Performance Influence Factors (PIFs)

A factor analysis was conducted to investigate the factors that affect the human error in disaster management. There were six factors examined in this study; they were an economic and social condition, knowledge understanding, preparedness planning, resources mobilisation, prevention action, action when the disaster occurs and the countermeasures of the disaster.

The result of correlation analysis between variables showed a strong relationship between some variables, for example, social, economic and knowledge understanding ($Z = 0.941$, $\text{sig} < 0.05$). KMO and Barlett test showed a valued of 0.825 (good) with significant value $\alpha < 0.05$. It means that data are feasible to be tested using factor analysis. All of MSA values based on Anti-image matrices also test > 0.5 . It means all of the independent variables can be further analysed. The final result of factor analysis showed that there was only 1 factor formed representing seven variables. They are an economic and social condition (0.957), knowledge understanding (0.968), preparedness planning (0.987), resources mobilisation (0.907), prevention action (0.977), action when the disaster occurs (0.636) and the countermeasures of the disaster (0.865).

4. Conclusion

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 is four detailed phase of the developed model. They are the identification of major disaster scenario, human error analysis, safety critical analysis, and performance influencing factors. The result of this study resumes a low level of residents' knowledge in disaster management. It is also found that the preparedness planning for the family, the implementation of the policy of local government as well as the function of executing unit in disaster mitigation are very limited and has not achieved the optimal condition.

The further study can be focused on the intervention of cognitive ergonomics in the community and other stakeholders to improve the preparedness and awareness state of disaster mitigation. Correlation and regression test can be conducted to investigate the correlation between the critical factors in disaster management and successful implementation of a human-centered model of disaster management. An AHP (Analytical Hierarchical Process) then can also be performed to determine the importance weight of factors influencing the human errors and to examine the preparedness level of the community in the disaster area. A checklist also can be designed to improve the usability of the model.

Acknowledgements

The authors thank Diponegoro University who funded the project "Desain intervensi kognitif untuk meningkatkan indeks kesiapsiagaan individu di daerah rawan longsor" within "Riset Pengembangan dan Penerapan (RPP)" scheme, Contract Number: SP DIPA-042.01.2.400909/2016, December 7th, 2015, with funding resource: DIPA PNPB of Diponegoro University 2016.

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