

The Hybrid Socio-Technical Approach as a Strategic Program for Social Development in Geo-disaster Prone Area in Indonesia

D. Karnawati, T.F. Fathani, B. Andayani and Suharto

Abstract—This paper highlights the importance of integrating social and technical approach (which is so called a “hybrid socio-technical approach”) as one innovative and strategic program to support the social development in geo-disaster prone area in Indonesia. Such program mainly based on public education and community participation as a partnership program by the University, local government and may also with the private company and/ or local NGO. The indigenous, simple and low cost technology has also been introduced and developed as a part of the hybrid socio-technical system, in order to ensure the life and environmental protection, with respect to the sustainable human and social development.

Keywords—Hybrid socio-technical system, indigenous technology, life and environmental protection, public education.

I. INTRODUCTION

INDONESIA is situated in such a dynamic geological conditions, so that it is frequently struck by various types of geological disasters, such as the earthquake, tsunami, volcanic eruption, landslide and debris flood. Unfortunately, this region is occupied by the high density of population, and those disasters continuously cause substantial death tolls, casualties, and socio-economical losses. According to [1], Indonesia has been struck by 6,632 events of natural disasters (mainly geological disasters), within the period of 1997 to 2009, with the total death tolls of 151,277 people. Therefore, it is very urgent to develop the society resilient in such disaster prone area.

Learning from several previous events of disasters, it is

apparent that most of the communities living in the disaster prone area are very vulnerable. They are not well-prepared to face the disaster due to several conditions, such as poor knowledge about the phenomena of disasters and about how to reduce the risks of any potential disasters. They also have limited skill and capacity to mitigate, monitor and recognize any early symptoms of disasters phenomena, which lead to the less capability to appropriately response to the disasters. Accordingly, the establishment of appropriate public education for capacity building to mitigate and prevent the disaster is urgently required to improvement the society resilient, in order to ensure the sustainable human and social development in this disaster prone area.

II. APPROPRIATE PUBLIC EDUCATION

A. Concept of Public Education

A strategic approach for public education in disaster risk reduction program is suggested by [2], with the schematic mechanism as illustrated in fig. 1. The community members, especially at schools and families, are the main target groups in such education program, and they are considered as the receiver of information. If this public education program can

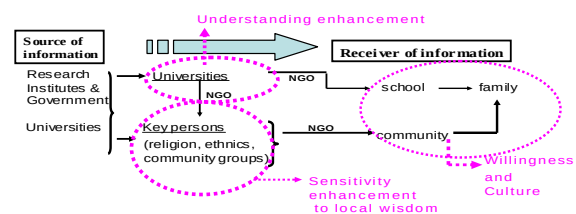


Fig. 1 Mechanism of public education for disaster risk reduction [2]

be successfully implemented, those target groups can be empowered as the driving agents for disseminating and transferring the information and knowledge within their own society, in order to stimulate the community willingness for disaster awareness and risk reduction.

By having strong willingness, a continued self- public education program then can be sustained to continuously improve the capacity and skill of the community, especially for effectively conducting the mitigation (prevention) and

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preparedness program, and eventually for developing the culture of awareness and safety.

In this public education, partnerships of the university / research institutes and Government play an important role as the source of information. Furthermore, the university partnerships with local NGO, private company and the local key person are required to stimulate the effective implementation of this public education program. However, those partnerships should be considered just as the initial actions for stimulating and facilitating the community empowerment. The hardest challenge in this community empowerment is to ensure that the empowerment program can be sustained by the local community them-selves, in order to self-stimulate the growing culture of awareness and safety. Accordingly, identification of local key persons is very crucial to establish the community driving agents for self-education program and for the development of "awareness and safety" culture.

B. Method of Public Education

The main objective of public education is to improve the society resilience by empowering them to prevent and minimize the risks of geo-disasters. This empowerment needs to be done through the improvement of knowledge about geo-disaster phenomena and how to reduce the risk of such disasters, and also conducted through the improvement of communal capacity and skill to practically implement their knowledge for the disaster risk reduction actions.

Accordingly, the awareness and willingness of community for conducting such actions can be stimulated by the process of improving knowledge and understanding. Without having strong awareness and willingness, effective and sustainable empowerment program cannot be performed.

Various approaches and methods can be applied for the improvement of knowledge and awareness. Transfer of information and knowledge about geo-disaster phenomena and its prevention method can be delivered not only in the class meeting and group discussions, but also through the informal activities such as through the cultural and spiritual events. The use of popular children-song, story, drawing and also various modified traditional performance, can be an effective tools for public education.

Improvement of community skill and capacity can be conducted through various enjoyable exercises. The skill to identify various types of vulnerable zones in the village area and to recognize the early symptoms of specific phenomena which potentially lead to the disaster, can be built through some field activities, such as by field trip, hiking, field camping, jogging and other sports program. Training or drilling for improving the community's skills for conducting emergency response, evacuation, and the first-aid medical response can be regularly conducted every month by involving all components in the village's society.

Nevertheless, social characteristics are unique due to the site/local specific conditions in terms of the ethnical and cultural point of views. Therefore, there is no single model or

generic approach and method for public education and social development program. That is why survey and mapping on the social conditions of each different ethnical and cultural groups are crucial to be carried out, before deciding the most appropriate approach and method for public education. Those survey and mapping provide information about community perception and expectation with respect to the public education and social development program. This identification stage is one key success factor in the social development program.

III. THE HYBRID SOCIO-TECHNICAL SYSTEM

A. Problem background

Various types of technology to support the disaster risk reduction program, such as for monitoring and early warning system, have been applied in Indonesia. However, the effectiveness of the implementation of such technology cannot always be guaranteed due to various reasons. One of most serious problems in the implementation of technology is the complexity (difficulty) and budget limitation for the operation and maintainance of the implemented technology. Eventhough, there is no access and capacity for the community to participate in the process of technology development, installement, operation and maintainance. Therefore, provision of appropriate technology, which is simple and low cost remains to be one serious challenge in disaster risk reduction program.

B. Concept of the Hybrid Socio-Technical System

To ensure the effectivity in the implementation of any technology for disaster risk reduction, a combined (hybrid) system which considers both social and technical conditions needs to be developed. Eventhough, it is recommended to develop the existing indigenous or local technology through public participation process. Indeed, one significant consideration in the technical aspect of the hybrid system is the simplicity of the system of technology, and the utilization of local material by local knowledge (local experts and local operators), through local participation program. All of this concept can be done only if the local community has been empowered. However, the process of technology development can be carried out during or as a part of the process of community empowerment. It is important that the hybrid system should be performed with a low cost and simple technology that can be easily understood, operated and maintained by the local community, such as suggested by [3].

IV. PILOT IMPLEMENTATION OF THE SOCIO-TECHNICAL SYSTEM

A hybrid socio-technical system has been implemented in one pilot area in Central Java, especially in Ledoksari Village at Karanganyar Regency. This Regency is situated at the western slope of Lawu Volcano, in which 30% of the region is highly risk for landslide due to the high susceptibility condition (indicated by red color in the map of fig.2) which is controlled by the geology and climate conditions, and also

because of the high vulnerability of the socio-economical conditions in the landslide prone area [4].

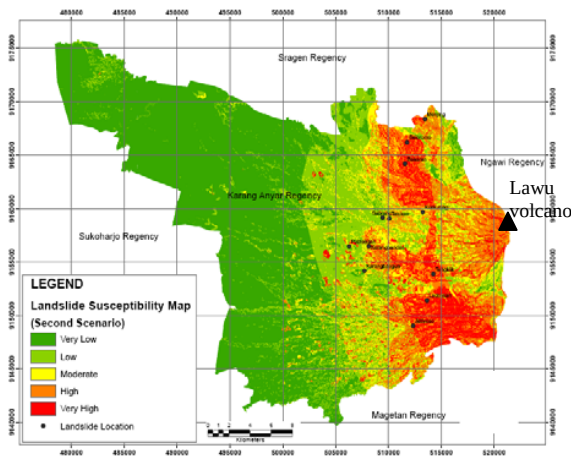


Fig. 2 Landslide susceptibility map of Karanganyar Regency, Central Java, Indonesia, developed in regional scale of 1 : 100,000 [4].

Admittedly, it is impossible to change the natural (i.e. geology and climate) conditions in order to reduce the landslide susceptibility, but it will be more feasible to manage the social conditions for reducing socio-economical vulnerability in the landslide prone area. Therefore, landslide disaster risk reduction in the pilot study area was conducted by adaptive management as suggested by [5] and [6], which emphasized on the improvement of community resilience, through the development of a hybrid socio- technical system.

A. Social System Development

Development of the social component in the hybrid system was initiated by public education with various target groups such as the women (as the key person in the family), teachers, children as well as the young and senior leaders. The local government of Karanganyar Regency also continuesly and actively supported this social development program.

To assure the effectivity of public education and the development of the hybrid system, social survey was carried out. The base level of community understanding on landslide phenomena and its prevention method, together with the community perception and expectation on the proposed developed-technology were also identified from the social survey. In addition, this survey found that most of the community members had been quite aware with the potential occurrence of landslides at the rainy season, because the landslide disasters have frequently struck their region, especially under the extreme weather conditions. Nevertheless, most of the community members preferred to remain living in their vulnerable region, instead of being relocated to the other safer areas. Obviously, the vertility of soil, the abundancy of water resources, the beauty of mountainous panorama and the strong psychological engagement with their homeland or home-heritage, have strongly prevented their willingness to leave their dangerous

homeland. Unfortunately, they do not have enough knowledge, skill and capacity to decide about “what should” and “what should not do” for preventing the landslide as well as for protecting their life and environment. Eventhough, they had not yet been capable to identify the sites (slopes) which were susceptible for landsliding and to recognize the initial symptoms for landsliding. Therefore, a simple hybrid socio-technical system for community-based landslide early warning was urgently required to protect their life.

Again, the hybrid system was developed by the combination of social and technical systems. Initiating by public education and community participation, the social system was developed through the establishment of community task-force for disaster risk reduction at the village level (fig.4), under the coordination with the Agency for Disaster Management at the Regency level. This network is also linked to the local hospital (health center), the local army and police, and also the Search and Rescue Team (SAR team) at the local Regency.

B. Technical System Development

The technical system for landslide early warning was supported by several sets of equipment listed below (fig, 5):

1. Rain gauge (1 set).
2. Manual extensometers (5 sets) with the siren alarm generated by dry battery (accu).
3. Solar panel (2 sets) to support the recharging of dry battery.

The rain gauge was installed in the open space to record the rain precipitation which potentially induced land-sliding. Such rain gauge was connected to an alarm and the alarm was set to be ON with loudly sound, when the accumulative rain infiltration had exceeded 100 mm. This critical number of rain infiltration was set based on the previous research conducted by [7] and [8]. The alarm due to rain gauge warning was deliberately designed to raise the community alert, to immediately prepare for evacuation before the landslide event.

In many cases it is apparent that crack at the ground surface always occurs prior to the landslide disaster event. Thus, the crack-extension can be used as the indicator of initial slope movement just before landslide occurs. That is why monitoring on the crack extension was implemented to provide the warning system prior to the event of landslide disaster. Accordingly, the extensometer was designed in the pilot area to monitor the extension of the crack, by allowing the wire of such extensometer to be pulled-able automatically across the crack, in response to the extension of crack induced by the slope movement (fig. 6). If the wire of extensometer was pulled up to 4 cm length (this length was defined based on the previous empirical analysis at similar susceptible landslide area), the connected alarm will give such loudly sound as the early warning to the community, so the community have to start to move away from the respective slope.

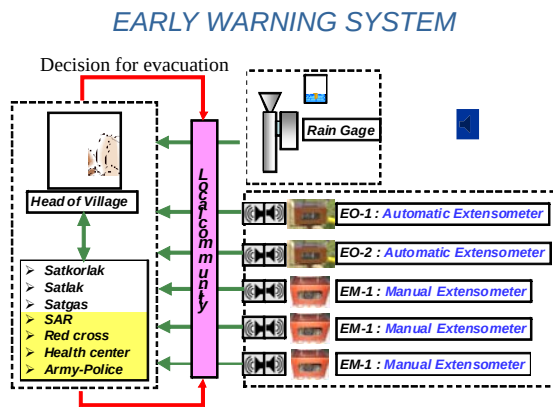


Fig. 4 A hybrid socio-technical system of landslide early warning and disaster risk reduction in Ledoksari Village, Karanganyar Regency, Indonesia [4].



Fig. 5 Early warning system equipments consist of a) manual extensometer with the control panel and syringe and b) rain-gauge [4].

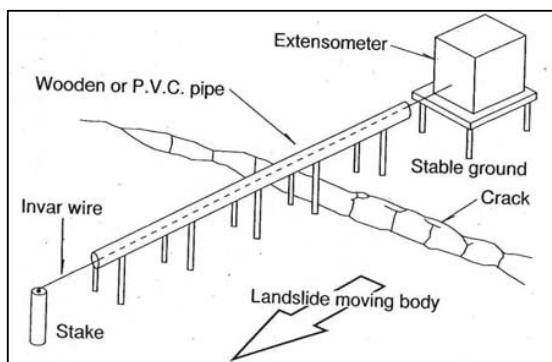


Fig. 6 Schematic performance of extensometer installed across the crack [9].

V.EVALUATION

Within two years of the implementation of this hybrid

socio-technical system, the performance of such system has been evaluated in terms of the advantages and limitations. Results of such evaluation are discussed below.

The community participation in the development process of this system has significantly stimulated the spirit and awareness of the community for landslide disaster risk reduction. This also encouraged them to take an important role in the disaster mitigation efforts. It is also evidence that the knowledge and skill for landslide prevention and early warning have been significantly improved through the community participation program.

However, it is quite challenging and time consuming to motivate the community to sustained their spirit and willingness. Some regular efforts may need to be conducted by through the regular meeting, discussion, or organizing a regular traditional-festival which can be integrated in the annual anniversary or independent day program.

The simple and low-cost technology produced as a part of a hybrid system has been proved to be easily installed, operated and maintained by the local community, however some danger may occur due to the wrong perception of the community. They may consider that the site or slope without any early warning equipment installation is always safe from landslides. In fact, there are still quite many slopes in the region which are potential for landsliding but no early warning equipment installed due to the limitation of budget. This misleading perception should be avoided by improving the community skill and capacity to recognize the symptoms of landslides, that can be indicated from various evidences without relying on the early warning equipment, such as from the appearance of spring or water seepage from lower part of the slope, the slope deformation, the inclination of trees, piles or structures on slope, as well as the ground cracking and subsidence along the edge or the the slope surface, etc.

VI. CONCLUSION

Learning from the preliminary evaluation on the ongoing implementation of a hybrid socio-technical system for disaster risk reduction, it is apparent that this innovative approach is quite significant to improve the effectivity of the sustainable human and social development program. Indeed, the establishment of community task force at the village level is very important to ensure the continuity and sustainability of this proposed system.

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REFERENCES

- [1] Anonym, "Landslide disaster database" Indonesian National Agency for Disaster Mitigation, 2009.
- [2] D. Karnawati, S. Pramumijoyo and K. Uchino, "Strategy and programmes for geological education in geohazard vulnerable area in South-east Asia and Japan (Published Book Style with paper title and editor)," in *Engineering Geology for Tomorrow's Cities*, Engineering Geology Special Publication, no. 22, M.G. Culshaw, H.J. Reeves, I. Jeffersson and T.W. Spink, Ed. London: Geological Society, 2009, (on CD Rom insert, paper 518).
- [3] D. Karnawati, T.F. Fathani, I. Sudarno, & B. Andayani, "Development of community-based landslide early warning system in Indonesia (Published Conference Proceedings Style)," in *Proceeding of the 1st World Landslide Forum*, Global Promotion Committee of The Int. Program on Landslide (IPL) – ISDR, Tokyo, 2008, pp. 305 – 308.
- [4] D. Karnawati, T.F. Fathani, I. Sudarno, B. Andayani and P.W. Burton, "Landslide hazard and community-based risk reduction effort in Karanganyar and the surrounding area, Central Java, Indonesia (Published Conference Proceedings style)," in *Proceeding of the 7th Regional Conference of IAEG (Int. Assoc. of Engineering Geology)*, Chengdu, China, 9-11 September 2009, p.436-441.
- [5] B. Andayani, D. Karnawati, & S. Pramumijoyo, "Institutional frame work for community empowerment towards landslide mitigation and risk reduction in Indonesia (Published Conference Proceeding style)," in *Proc. of the 1st World Landslide Forum*, Tokyo, Global Promotion Committee of the Int. Program on Landslide (IPL) – ISDR, 2008, pp. 57-59.
- [6] D. Karnawati, T.F. Fathani, B. Andayani, P.W. Burton and I. Sudarno., "Strategic program for landslide disaster risk reduction; a lesson learned from Central Java, Indonesia (Published Book Style with paper title and editor)," in *Disaster Management and Human Health Risk; Reducing Risk, Improving Outcomes*, WIT Transactions on the Built Environment Transaction, K. Duncan and C.A. Brebbia, Ed. Southampton: WIT Press, 2009, pp.115-126.
- [7] D. Karnawati, " Mechanism of rain-induced landslide in allovanic and halloysitic soils in Java (Unpublished Book Style)," *Ph.D Dissertation*, 1996.
- [8] T.F. Fathani, D. Karnawati, K. Sassa and H. Fukuoka., 2008. Development of landslide monitoring and early warning system in Indonesia (Published Conference Proceeding style)," in *Proc. of the 1st World Landslide Forum*, Tokyo, Global Promotion Committee of The Int. Program on Landslide (IPL) – ISDR, 2008: pp. 195 - 198.
- [9] Japan Landslide Society, 1996.