RISK MANAGEMENT IN DAM BREAK DISASTER: LESSONS LEARNED FROM WAY ELA NATURAL DAM BREAK

FT Yunita 1, D.A. Puspitosari2
1Water Resources Research Center, Bandung, Indonesia
Email: f.t.yunita@alumnus.rug.nl
2 Water Resources Research Center, Bandung, Indonesia

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ABSTRAK


Kata Kunci: Manajemen resiko, bencana keruntuhan bendungan, bendung alam, mitigasi bencana.

ABSTRACT

Indonesia is situated in the Pacific Ring of Fire with high potency of natural disaster, such as earthquake. The earthquake may trigger dam failure. Meanwhile, Indonesia rapid population growth results on the increasing needs for space. Thus, settlements expand to prone area. The global climate trend recently shows greater natural disaster. Considering these facts, this paper emphasized the importance of dam break preparedness for the downstream community by taking Way Ela Dam Break as a case study. The results demonstrate that the downstream of the dam is a prone area. Therefore, early warning and evacuation scheme for dam break must be developed. This strategy requires a clear disaster risk map and individual acceptance and responsibility. Insurance scheme can be considered for infrastructure and properties damages. Spatial plan and regulations in hazard area is required as control. The local capacity must be improved to minimize their dependency to central government.

Keywords: risk management, dam break disaster, natural dam, disaster mitigation
GENERAL

Background

Indonesia, as other developing countries in the world, has to deal with the problem of rapid population growth. According to Indonesia Central Bureau of Statistic (CBS) following the last official census the population of Indonesia in 2010 was about 237 million people and most of them are living in Java Island (57.49%) (Rachmawati and Suhartanto, 2014). It is expected that in 2020, the population will reach 254 million and by 2050 the population will touch 285 million, despite the program enhancement of family planning. However, the population is already estimated to be capable of reaching 248 million by July 2012 and that represents a significant rise from the official 2010 figures (Beets, 2009; Mason et al., 2005).

The population growth has consequence on the increasing human demands for settlement, agriculture and food products and other raw materials. It means that people will need more space to accommodate their activities in fulfilling their needs as it is reflected by the extensive land use changes particularly from natural land resources into artificial landscape. This pattern is also facilitated by the improvement on recent construction technologies that enable people to build structures in prone areas, such as steep slopes or fragile soils. As a result, today more people dare to live in vulnerable areas, which used to be avoided, such as flood plain, hilly area or even at the downstream of dams (see Figure 1).

The landscape extensive changes caused by human activities, has decreased the environmental service capacity. It is indicated by the occurrence of natural disasters especially that related to climate variability. In fact, that sort of disasters is globally increasing in frequency and magnitude. Figure 2 presents the disaster statistics in Indonesia from 1815 to 2013 published by National Agency of Disaster Mitigation and it shows the increasing pattern of disaster occurrences and victims. Natural disasters that mostly occurred are flood and land slides.

One of disaster that attracted national or even international attention in 2012 was Way Ela Natural Dam Break. It was formed by a huge landslide in Ulu Hatu Hill. The Way Ela Natural Dam Break has opened our mind that such a great disaster or even greater ones will possibly occur in the future.

Figure 1. Settlement on flood plain along Code River in Yogyakarta

Figure 2. The statistics of disaster occurrences (blue) and victims (yellow) in Indonesia (1815-2013)
Source: BNPB, 2013
Natural forces work beyond our design planning.

Learning from the experience, it is important to understand that there will be more uncertainty and unpredictability in the future. Regarding to the facts, our preparedness will play important role in reducing disaster risks. Therefore, to recognize the degree of our preparedness at local and national level, an assessment on our readiness in coping with sudden disaster, especially for dam break case, has to be conducted in order to identify the strengths and weaknesses in our strategies.

Problems

According to Komite Nasional Indonesia untuk Bendungan Besar or Indonesian National Committee on Large Dams (INACOLD), Indonesia has 284 dams categorized as large dams (Syafputri, 2012). In dam safety design, there is no tolerance for the possibility of dam break. Meanwhile, Indonesia has a high potency of natural disaster that might triggered dam break since its location is situated in the Pacific Ring of Fire. Moreover, every design structure indeed has their own limited capacity. Thus, there is no guarantee that it is safe living in the downstream of a dam. However, this potency of disaster is not fully realized or even ignored. Table 1 below shows the size of Way Ela Dam compared to several large dams in Indonesia. The comparison illustrates the potency of disaster that can be caused by dam break, which is determined by its size and reservoir capacity. The greater the dam capacity, the area that will be affected by flood inundation will be larger and the damages will be worse as well.

On the other hand, Indonesia has experienced political changes for more than 10 years, related to the shifting of authority from central to local level, in which the local government has more authority in taking actions at the micro level. Meanwhile, many disasters occurred in remote areas, in which the local government should take responsibility. However, in many cases of dealing with disasters, the central government still play important role.

Objectives

In Way Ela Dam break case, the share role of local and central government responsibility in the countermeasure effort will be used to depict the stage of national readiness in coping with sudden disaster, such as dam break case. By understanding the current stage, the weaknesses can be identified as the starting points for further improvement in the future.

LITERATURE REVIEW

The Public Safety Awareness

The dam safety was became an important issue in several countries during 1990’s, following some serious public safety accidents. The emerging of issue was triggered by the increasing of public safety awareness. In France, it was Drac river accident, downstream of the Notre-Dame-de Commiers dam, in 1995, which became an important driver for significant public safety development (Petitjean, 2012). In Norway, a tragic fatal accident in hydro power station intake of dam occurred in 1989 accentuated the need of a comprehensive and systematic public safety in the country some years later (Honningsvåg, 2012).

In United States, dam safety issue emerged earlier in 1972, after the failure of three coal-slurry impoundment dam in West Virginia and the failure of Canyon Lake Dam in South Dakota, which caused catastrophic disaster. Those dam break events had forced the enacting of the National Dam Inspection Act (NDIA, P.L. 92-367, August 8, 1972) (Galloway, G.E. et al., 2011). The following of several dam failures during 1970s to 1980s also led the issue of dam safety to become serious national problem. These culminated in the National Dam Safety Program (NDSP), established by the National Dam Safety Program Act of 1996, which is coordinated by the Federal Emergency Management Agency.

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of Dam</th>
<th>Location</th>
<th>Height/Width (m)</th>
<th>Reservoir Capacity (m³)</th>
<th>Compared to Way Ela Dam Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jatiluhur Dam</td>
<td>West Java</td>
<td>105.00m/10.00m</td>
<td>1,790.00 million</td>
<td>116 times</td>
</tr>
<tr>
<td>2</td>
<td>Jatigede Dam</td>
<td>West Java</td>
<td>110.00m/12.00m</td>
<td>980.00 million</td>
<td>64 times</td>
</tr>
<tr>
<td>3</td>
<td>Batutegi Dam</td>
<td>Lampung</td>
<td>122.00m/12.00m</td>
<td>690.00 million</td>
<td>45 times</td>
</tr>
<tr>
<td>4</td>
<td>Wonogiri Dam</td>
<td>Central Java</td>
<td>40.00m/10.00m</td>
<td>440.00 million</td>
<td>29 times</td>
</tr>
<tr>
<td>5</td>
<td>Karangkates Dam</td>
<td>East Java</td>
<td>97.50m/13.70m</td>
<td>253.00 million</td>
<td>16 times</td>
</tr>
</tbody>
</table>

Source: Research and Development Center for Water Resources, 2006
The purpose is to ensure the public and property owners downstream of potentially deficient dams be informed of the risk from dam failure (Plisich, J., 2014). The activities are including (Plisich, J., 2014):

- State assistance by grant funds to strengthen their dam safety program;
- Research and development identify effective techniques to assess, construct and monitor dams;
- Collaboration training and technical transfer for dam safety professionals and dam owners;
- Arrangement of technical manuals, guidelines and tools for dam safety;
- Public awareness and outreach on dam safety issues.

The strategies applied by conducting those activities are (Ingram, 2012):

- Reducing the likelihood of dam failures;
- Reduced the potential consequences in the event of dam failures;
- Promote public awareness of the benefits and risks related to dams;
- Promote research and training for state dam safety and other professionals; and
- Align relevant federal programs to improve dam safety.

The NDSP has promoted some innovative strategies. If conventional strategy is used to focus on risk reduction, the NDSP has studied the possibility of transferring risk using flood insurance scheme.

While U.S. the national agency has an important role in enforcing and developing the dam safety actions by advance programs. in other countries the regulation of dams is the responsibility of the regional authority, for example in New South Wales (NSW), Australia. The dam failure planning in NSW was initiated by Dams Safety Committee by releasing the list of dams in critical condition. The Committee then pushed the authorities of those high-hazard dams to have plans for anticipating dam break event. (Tamworth Regional Council, 2013).

Dungowan dam is one of those high risk dams. It is located approximately 50 kilometres south-east of Tamworth with storage capacity of 6,300 ML and supplying up to 50% of the Tamworth’s water requirements (Tamworth Regional Council, 2013). In dealing with the risk of dam failure, according to Tamworth Regional Council the following actions was taken:

- Relocating downstream properties in high risk zone.
- Building new or upgrading existing flood refuge structures.
- Developing early warning system by using telemetry between various gauges to monitor the trigger points.
- Using multimodal system to deliver warning information, e.g. SMS, voice, email, web, mobile or social media.

The countermeasures taken on Dungowan Dam was lead by local authorities and communicated to the community through one-on-one meetings with a number of residents plus two community information sessions for other local residents (Leyonhjelm, 2014). Based on the meeting, the option for relocating some properties will face resistance from the residents, especially for those that have stayed there for a long period of time.

Dam Safety Mitigation Strategy

There are three main strategies of disaster risk management approach that have been already identified (Kron 2002, Petry 2002, Van Alphen 2005, Oosteberg 2005), in general we renamed those as:

- "keep disaster away from people"
- "prepare people from disaster"
- "keep people away from disaster"

The "keep disaster away from people" strategy approach stresses on preventing the hazard reach the community. This strategy has become the main stream of disaster risk management in all cases for a long time. In Dungowan Dam case, it is showed by constructing the flood refuge structures which will direct the flood away from the settlement.

Meanwhile, the strategy of "keep people away from disaster" was introduced in the believe that we have to give more space for the nature to accommodate its activities, thus the community has move out from hazard area in order to avoid conflict of both activities. This strategy is not so popular because it can trigger friction conflict with the community as happened in Tamworth.
Every countries has one way or another for managing their public safety risks and some are developing more systematic methodologies. In general, mitigation measures comprise relevant structural and operational adjustments, access barriers, warning systems, and as well as education and information to the public for better understanding the hazards involved and avoiding dangerous behavior.

To deliver a good risk management for dam break disaster in Indonesia, an assessment to the system readiness is necessary. In this paper, the effort for public safety in dam break case in Indonesia is depicted and classified into those three strategies to overview at which level the strategy in Indonesia has been implemented and whether there is possibility to improve the system.

**RESEARCH METHODE**

**Methodology**

This research is based on qualitative method. The qualitative content analysis is employed to grasp the relevant information. It is a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding, including summarizing, explicating, and structuring the textual material (Flick, 2006).

This research also apply a case study method by choosing Way Ela natural dam disaster as a case study area to examine the countermeasures that had been taken in dealing with possibility of dam break.

The method of data collecting is by observing in the field and interviewing local authorities to reveal the action that has been taken during the emergency response.

To analyse, data and information are mapping and classified into the implemented strategy and risk reduction approach, measures, institutional supports and other necessary instruments.

The literature review was also conducted as the basis of analytical method in the discussion of strengths and weaknesses of the strategy. Finally, conclusions of the national readiness in dealing with catastrophic disaster were drawn.

**The Way Ela Natural Dam Case Study**

The landslide occurred on July 13, 2012 has formed natural dam. The location of Way Ela Natural Dam is in Negeri Lima Village, Leyhitu District, Central Maluku Regency, Maluku Province. (Figure 3).

The landslide triggered by 360 mm rainfall intensity (recorded at Pattimura Rainfall Station). The landslide material consists of the weathered breccia, tuff and andesite and the geological condition in this area is dominated by volcanic deposit. The landslide material has formed Way Ela natural dam along the river. The natural dam dimension is approximately 1000 m length, 200 m width and 210 m height. The volume of sliding was estimated at around 10 million m3. (Puslitbang SDA, 2012).

There are two main factors that influence the occurrence of landslides in Ula Hatu Hill, internal and external factors (Balai Sabo, 2013). External factors are the slope of river banks larger than 800 and the erosion on the slopes of river banks. Meanwhile internal factors are the increase of pore water pressure and the increase of soil moisture content.

The central and local government had conducted several countermeasures, including emergency spillway, toe drainage, and early warning system (Taufik, A., 2013).

a) Emergency Spillway (Figure 4)

Emergency spillway was constructed to prepare for overtopping. The design concept of emergency
spillway:

1. The spillway elevation was +197 m, the capacity of reservoir was 15.42 million m³.
2. The spillway dimension was designed for 100 year return discharge period with, the discharge capacity of the spillway is 18 m³/s.
3. The spillway was designed with round shape sill and the spillway with 4 unit of energy dissipation structure (MDO type).
4. The materials of spillway consist of concrete mat, concrete and strengthened with bamboo pile and GCL.

b) Pumping System (Figure 5)

The aims of pumping works were to decrease the water level so that it will not exceed the safe level that might cause the dam break. The capacity of pumps was 250 liter/sec.

c) Toe Drainage (Figure 6)

The drainage of landslide toe was done by installing PVC pipe. The purpose is to reduce the water pressure to the dam.

Early Warning System

The early warning system for the possibility of dam break was initiated by the central and local government which is (Puslitbang Sumber Daya Air, 2013):

a) Rainfall and Water Level Monitoring (Figure 7)

The early warning system was established by installing rainfall and water level gauges. The early warning system was implemented in order to...
monitor water level and rainfall around the natural dam.

b) Deformation Measurement (Figure 7)

The Monitoring of land deformation and dam stability was done by installing shear pegs at 4 locations. The monitoring of water seepage was done by installing V-notch.

c) Wire Sensor (Figure 8)

The wire sensor was installed in order to monitor the occurrence of debris flow. The wire sensor was installed in the river at the downstream of the dam. When the debris flow occurred, the debris flow will attack the wire sensor and it breaks, after that the break of wire sensor will trigger the system activate the siren, and the people start evacuating.

d) Evacuation Scheme (Figure 9)

Evacuation route has been designated by the local government in order to let the people understand the shortest route for evacuation. The evacuation information was installed at the several places in the village.

RESULT AND DISCUSSION

Strategy Approach

The strategy in Way Ela Natural Dam was taken on the basis of conserving the natural dam. The justification of this option was laid on the thinking that demolished the natural dam has high risk since many people live in the downstream. The approach refers to the “keep disaster away from people” strategy, since it focused on preventing flood occurrence. The main actor of this strategy is the Water Sector of Ministry of Public Works. However, this option was very risky by considering that the natural dam itself was formed by a weak deposition of landslide. Thus, a backup plan for the the worst case of natural dam break was also conducted through the installation of early warning system and dissemination of evacuation scheme. This approach is more likely as the “prepare people for disaster” strategy. Move people in the downstream out from hazard area which refers to the third approach was not an option in this case, as well as other similar cases, since there will be more resistance from community if the option was taken.

Risk Reduction Approach

The efforts of all measures taken in disaster situation are due to reduce its risk. Many approaches try to formulate disaster risk. For instance, the disaster risk is illustrated as two elements: disaster probability and potential damages caused by it. Another one that commonly used describes risk in three factors, hazard, vulnerability and exposure (Kron 2002), where hazard is related to disaster probability, vulnerability is unprepareness for disaster and its consequences, and exposure is capital and population in disaster area (Oostebergh 2005).

These three factors can then be inverted into three main disaster risk reduction:

- hazard reduction which is in line to “keep disaster away from people”,
- vulnerability reduction which is in line to “prepare people for disaster”, and
- exposure reduction which linear to “keep people away from disaster”.

Figure 8. Wire sensor (left) and evacuation information (right)

Source : Field Photograph, 2013
The disaster risk reduction approach in Way Ela natural dam case tends to eliminate the risk by reducing its hazard and vulnerability, rather than reducing exposure. The hazard reduction programs was showed by spillway construction that built to retain the landslide deposition and water in its place since they may become a hazard if released to downstream. Meanwhile, the risk reduction that related to vulnerability is the efforts on preparing community at the downstream for the possibility of dam break and improving their capacity in facing that.

**Measures Classifications**

Measures are one or more concrete actions or programs to reduce risk. Therefore, measures are tangible elements of a risk reduction strategy (Oostebergh 2005). Thus, the amount of reduction of each elements can be estimated and the limitations must be clear.

As being explained previously, that the risk reduction in Way Ela Natural Dam consist of hazard and vulnerability reduction. In many cases, generally the hazard reduction is conducted by mean of technical measures, however in this case we may also find some spatial measures applied.

The technical measures applied in Way Ela Natural Dam were:

- Emergency spillway construction
- Pumping system
- Leakage prevention (toe drainage and geobag)

The emergency spillway was constructed in order to prevent the landslide deposition and retained water at its upstream run down to the village. If this measures were worked properly, then the risk would be reduced, additionally it will give advantages to the surrounding community since it might provides water supply and electricity. However, it took time to built the permanent dam while the upstream water level continue to increase which endangers the stability of the natural dam if it exceeds the safe level. To keep the water level at the safe stage, the pumping system was installed to minimize the possibility of dam failure. The dam failure can also be triggered by leakage. Therefore, to prevent dam failure risk caused by leakage, toe drainage and geobag were applied.

Instead of technical measures, some spatial measures were also taken in Way Ela Natural Dam. The spatial measures are modification on spatial appearance due to provide room for potential hazard. The measures include in th preserving reservoir at the upstream of natural dam and the counterweight and cutting as well for dam stability.

The existence of reservoir will change the spatial function of the area from forest and agriculture land into inundated area.

The effort on vulnerability reduction implemented in Way Ela Natural Dam was classified as emergency response, consist of:

- Monitoring water level and deformation
- Early warning system
- Evacuation scheme

Monitoring water level and deformation were conducted in order to observing the indicators for emergency response in case of dam break. Those indicators determined the evacuation time for people at the downstream. The accuration and time lag of information sent by sensors were important factors in minimizing the risk. Meanwhile, early warning system and evacuation scheme reduced the risk of affected lives caused by dam break. The effectiveness of those measures is relied on the prepareness of community and the related evacuation facilities.

**Institutional Supports**

The implementation of measures requires institutional support in order to achieve the risk reduction (Oostebergh 2005). The technical and spatial measures calls for a strong water sectors, with a clear mandate and secure financing. In the case of Way Ela Natural Dam, the local water management has not ready to deal with such a catastrophic disaster since its resources and capacity are limited. Therefore, the central government with the hand of water sectors of Ministry of Public Works took over the responsibility, although the disaster itself is located in the authority of Maluku Province. The budget for the technical measures was mostly obtained from central government and international funding.

On the other hand, the emergency measures tend to require more local acceptance and responsibility, especially from individuals which are potential victims. Community understanding is needed regarding the potential risk that they have to deal. Consequently, the responsibility of the community to take actions in helping themselves is required as well as the consequences of living in hazard area. Therefore, these measures need participation and cooperation of local people to help themself in preparing for the worst. The leadership of these measures should be taken by local government as the authority owner, such as Pemerintah Daerah (PEMDA) Maluku (Local Goverment) and Badan Penangulangan Bencana Daerah (BPBD) Maluku - Local Agency of Disaster Mitigation.
However, in Way Ela coordination of emergency response action was taken by Badan Nasional Penanggulangan Bencana (BNPB) – National Agency of Disaster Mitigation, as the Way Ela Natural Dam was issued as National Disaster. Under coordination of BNPB, the contingency plan was arranged with participation of Directorate General of Water Resources (Ministry of Public Works), Local Government, Local Agency of Disaster Mitigation, TNI (Indonesia National Army), POLRI (Police) and local community.

**Instruments Applied**

Instruments are governance tools to achieve these measures, for examples plan, law, information, mandate, financial, etc (Oostebergh 2005). Thus, instruments to support the emergency response are important factors to achieve goals and impacts. Instruments ensure the measures taken will be in order as it was planned. For example technical measures usually require strong financial supports due to the physical construction, meanwhile early warning system and emergency response need instruments such as hazard map, information board and also dissemination of evacuation plan to deliver the system successfully.

As well as in Way Ela, in December 2012 Balai Wilayah Sungai (BWS) Maluku, which has the authority of river management in Maluku, arranged Rencana Tindak Darurat (Emergency Response Plan) in collaboration with other stakeholders. The plan consists of two main strategies: technical measures and early warning system. Since technical measures such as dam construction is a large works of infrastructure then surely it takes a high cost construction. It also requires a strong engineering support, which is represented by Puslitbang SDA as the mandate owner for engineering decision and judgement. Early warning system in Way Ela, was a high technology system which is financed by Japan Government. The system was also supported by evacuation dissemination, in which the evacuation information was communicated to the people in the downstream of Way Ela Dam.

**Risk Management in Indonesia**

In dealing with Way Ela Natural Dam Break, the Local and Central Government had conducted risk management in order to minimize the losses caused by dam break. The summaries of the approach that was taken during the emergency response is mapping and classified in Table 2 below. Although this table illustrates the strategies in Way Ela Dam Break Case, however it may partly depict the risk management pattern in Indonesia. The risk reduction approach mostly focuses on hazard reduction by implementing technical measures. Strategy on vulnerable reduction is not fully explored, it is conducted only by initiating early warning system and evacuation scheme. On the other hand, the exposure reduction is still not a favorable option. It is reasonable since it may cause more social friction and rejection rather than other approaches.

**Table 2. The mitigation approach mapping of Way Ela Natural Dam Countermeasures**

<table>
<thead>
<tr>
<th>Strategy approach</th>
<th>Keep disaster away from people</th>
<th>Keep people away from disaster</th>
<th>Supplier of goods</th>
<th>Risk reduction approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk reduction</td>
<td>Keep disaster away from people</td>
<td>Prepare people from disaster</td>
<td>Keep people away from disaster</td>
<td>Supplier of goods</td>
</tr>
<tr>
<td>approach</td>
<td>Disaster probability reduction</td>
<td>Early warning &amp; emergency measures</td>
<td>Adjusting the structure of houses and infrastructures</td>
<td>Insurance scheme</td>
</tr>
<tr>
<td>Measure approach</td>
<td>Technical measures</td>
<td>Spatial Measures</td>
<td>Early warning measures</td>
<td>Adjusting the structure of houses and infrastructures</td>
</tr>
<tr>
<td>Countermeasures</td>
<td>- Constructing spillway</td>
<td>- Conserving natural dam as reservoir</td>
<td>- Monitoring water level &amp; deformation</td>
<td>- Adjusting the structure of houses and infrastructures</td>
</tr>
<tr>
<td>Institutional</td>
<td>- Strong sectoral water management (Balai Wilayah Sungai Maluku)</td>
<td>- Expertise groups (Puslitbang SDA)</td>
<td>- Individual and local acceptance and responsibility.</td>
<td>- Good cooperation and coordination between local and central authority.</td>
</tr>
<tr>
<td>supports</td>
<td>- Secure Finance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instruments applied</td>
<td>- Legal Mandate</td>
<td>- Secure Finance</td>
<td>- Dissemination and sign board of evacuation information.</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Analysis, 2014
As mentioned in the beginning, those three strategies are variables in controlling the disaster risks. As the function of risks, those variables will influence each other. The result of the influence may decrease or increase the risks. Therefore, before implementing a strategy, it is important to have a complete understanding on their behaviour. For example, the implementation of technical measures such as dams which is supposed to reduce the flood risk. Indonesia has many large dams implemented due to flood control. Theoretically, the hazard is controlled which means the risk is reduced. Since the downstream area becomes "safe" from flood, people will live in those flood area which results on the increase of exposure and vulnerability. The "false sense" of safety has encourage more people and investment in the flood area. The frequency of potential disaster has reduced but the potential damage to live and goods has increased, thus the impression of complete safety is therefore false (Smits, A.J.M., et al. 2006). At the end, the objective of the strategy which is to reduce flood risk is not achieved. Figure 7 shows how a strategy implemented without understanding the whole system that involved.

Additionally, although the legal aspect of disaster mitigation at the national level, e.g. the law number 7/2004 and the law number 24/2007, have already issued, the consequent disaster mitigation strategy has not fully implemented, especially at the local level. Only few that has already equipped the laws with local regulation and strategy mitigation. The local institution in dealing with disaster has been established but it has short of competent human resources. Therefore, the dependency level of local to central government is still high.

**Improvement on Risk Management**

Regarding to the previous discussion, there are some opportunities that can be taken to improve the risk management in Indonesia. But firstly, it is important to understand that Indonesia has a high potency of natural disaster, such as flood, earthquake, landslide, etc., because of its geography and geological condition. From that point, there is potency of disaster caused by dam break, in case the magnitude of disaster exceed the design capacity of dam. Therefore, we need to prepare for the worst by making a risk management plan for dam break disaster.

Learning from Way Ela Natural Dam Break risk management, there are some strategies which are not fully explored. The proposed improvement on the risk management are:

1. **Vulnerable reduction approach:**
   a. Adjusting the structure of houses and infrastructure at the hazard area to increase their structural bearing capacity.
   b. Insurance scheme for the livelihood and investment in the hazard area

2. **Exposure reduction approach:**
   a. Controlling the development in the hazard area.
   b. Permanently evacuating people out of hazard area.

However, to implement these strategies the enabling environments including policies, laws and regulations are required, for example infrastructure and building code, insurance for disaster policy, regulation on landuse and development permission.

Finally, the role of local actors in executing and monitoring the risk management strategies at the micro level is important. Therefore, the capacities of related local institution have to be improved to minimize their dependency to central government.
CONCLUSIONS

In summary, the lessons we have learned from the Way Ela Dam Break Case have led us to conclude some recommendations and visions to improve our strategies in dam safety and risk management in Indonesia.

First, we have to change our “false sense of safety” perspective and start to realize that the downstream of the (large) dam is a high risk area related to the possibility of dam break.

Second, there has to be risk assessment and risk management plan to cope with possibility of dam break. Early warning and evacuation scheme for dam break disaster has to be established, as risk reduction strategy. This risk reduction strategy has to be supported by a clear disaster risk map, evacuation information and individual acceptance and responsibility.

Third, an insurance scheme can also be considered in managing the risk for infrastructure and properties damages. However, the most important is to control the development and investments in the risk area to minimize the exposure factors, therefore spatial plan and development regulations is required.

The last but not the least, the capacity of local actors in the risk management strategy has to be improved to minimize their dependency to central government because of their important role in executing and monitoring at the local level.

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