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Review:

Multi-Disciplinary Hazard Reduction from Earthquakes and Volcanoes in Indonesia

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Indonesian and Japanese researchers have conducted a three-year, multi-disciplinary, cooperative research project. The project provides a platform for collaboration among researchers in natural science, engineering, and social or humanity sciences, and for officials in national and local governments. Research activities are grouped into (1) evaluation of earthquake potential and prediction of strong-motion and tsunami hazards based on geophysical investigations, (2) short-term and long-term predictions of volcanic eruptions and development of methods for their evaluation, (3) establishment of social infrastructure based on engineering developments, (4) mitigation of social vulnerability to geohazards, and (5) promotion of disaster education and raising of disaster consciousness. To coordinate these research activities and to utilize the research results, the project has one last group, (6) application of the research and establishment of a collaboration mechanism between researchers and government officials. In addition to research collaboration in individual fields, inter-group meetings and workshops are regularly held to promote inter-disciplinary discussion and collaboration. Multi-disciplinary surveys on recent volcanic and tsunami disasters have also been conducted. The Joint Coordinating Committee, composed of representatives of relevant Indonesian ministries and institutions as well as project leaders, oversees the unique multi-institutional and multi-disciplinary activities. This committee can be maintained after the completion of the project as a platform for Indonesian stakeholders.

Keywords: Indonesia, earthquake, tsunami, volcanic eruption, natural hazard

1. Introduction

Since 2008, the Japan Science and Technology Agency (JST) and the Japan International Cooperation Agency (JICA) have jointly started the Science and Technology Research Partnership for Sustainable Development (SATREPS). The purpose of this program is to acquire new knowledge that leads to the solving of issues of global scale to improve the level of science and technology based on the needs of developing countries, and to implement these achievements in society in the future. Natural disaster prevention is within the scope of these projects, along with environment and energy, bioresources, and infectious disease control.

We have been conducting as one of the first projects supported by SATREPS, a collaborative project entitled "Multi-disciplinary Hazard Reduction from Earthquakes and Volcanoes in Indonesia." This issue of J. Disaster Research is devoted to this project; it consists of 11 research papers and this introduction. In this introductory paper, we describe the project's background and briefly introduce its activities, with emphasis on cross-disciplinary activities. Research results of individual aspects are presented in other papers.

2. Natural Hazards in Japan and Indonesia

Japan and Indonesia are both located on tectonic plate boundaries. Hence both countries have suffered from large earthquakes and volcanic eruptions (**Fig. 1**). The two largest earthquakes in the world during the last 50 years, the 2004 Sumatra-Andaman earthquake (M9.1) and the 2011 Tohoku earthquake (M9.0) occurred in and affected Indonesia and Japan, respectively. Tsunamis from these giant earthquakes caused fatalities in the hundreds of thousands in Indonesia and in the tens of thousands in Japan. In addition, inland earthquakes, such as the 1995 Kobe earthquake (M7.3) or the 2006 Yogyakarta earthquake (M6.3) have caused thousands of fatalities in large cities. Furthermore, both countries have more than one hundred active volcanoes, many of which have erupted recently. For example, the Merapi volcano erupted in 2006 and 2010 causing hundreds of fatalities.

Because large populations are at risk from these frequent disasters, natural hazards and disaster prevention are some of the highest priority issues in both coun-

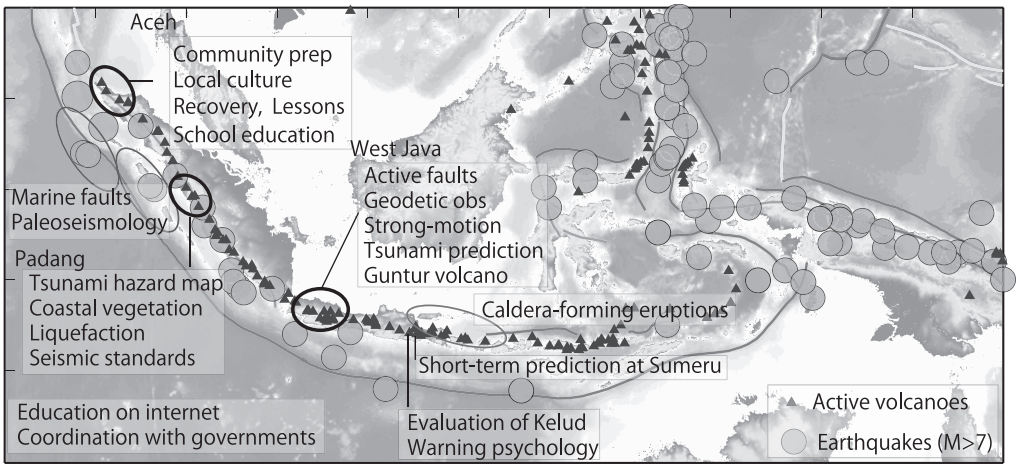

Fig. 1. Earthquakes and volcanoes in Indonesia. Target areas and activities of 22 subgroups in this project are also shown.

tries. They are similar in that many government ministries, agencies, and organizations participate in disaster prevention. In Japan, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and other ministries such as the Ministry of Economy, Trade and Industry (METI) are promoting basic research on natural hazards, while the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is responsible for the implementation of disaster prevention. In Indonesia, the organizations are the State Ministry of Research and Technology (RISTEK), the Ministry of National Education (DIKNAS), the Ministry of Public Works (PU), the Ministry of Energy and Mineral Resources (ESDM), the Ministry of Marine Affairs and Fisheries (DKP), and the Ministry of Communication and Information Technology (KOMINFO). There are equivalent governmental agencies in specific fields in both countries, such as the Japan Meteorological Agency and BMKG, the Geographical Information Authorities in Japan and BAKOSURTANAL, just to name a few. Coordination among these ministries and agencies as well as among universities is essential in both countries.

There are some differences between Japan and Indonesia. Indonesia is the world's largest Islamic country, but it also consists of diverse cultures and ethnic groups, while Japan is more uniform culturally and ethnically. Such cultural and social differences are also reflected in time of disaster.

Against this background, several organizations and universities in both countries have been building cooperative relationships for a long time in individual fields related to natural disasters, such as earthquakes or volcanoes. In addition, both governments agreed in 2006 to collaborate on disaster reduction [1].

3. Project Groups and Their Activities

The ultimate purpose of this project is to mitigate the damage from earthquakes and volcanic eruptions in both Japan and Indonesia. In order to achieve this goal, the project must be a comprehensive one that consists of natural science research regarding hazards, engineering and social or humanity science research related to social vulnerabilities, research and practice in disaster prevention education based on these research results, and collaboration with the governments to make use of these achievements. For this reason, almost one hundred researchers from each country are participating in this project. In addition, this project is supported on both sides by JST and JICA in Japan and RISTEK and LIPI (Indonesian Institute of Sciences) in Indonesia. Specifically, there are 22 subgroups under the 6 groups shown in **Fig. 2**, and participants include ones other than the organizations and universities listed in the figure. In this section, each group and subgroup is briefly introduced.

3.1. Evaluation of Earthquake Potential and Prediction of Strong Motion and Tsunami Hazards Based on Geophysical Investigations (Group 1)

Group 1 targets earthquakes and tsunamis based on a natural science approach. The group is investigating past earthquakes and tsunamis that affect the islands of Java and Sumatra, monitoring the present condition of the earth's crust by geodetic observations [2] and marine surveys, and aiming to predict strong ground motions and tsunamis resulting from future earthquakes [3]. The group consists of the following six subgroups.

G1-1: Study of historical earthquakes based on active fault surveys

For the long-term forecasting of large earthquakes on land, this subgroup conducts geomorphological and paleoseismological studies on the Lembang fault on Java. This group has clarified the basic parameters, i.e., the fault length (27 km), slip rate (1 m/ka in vertical direction) and past activities (three events in the last 13 ka, with the

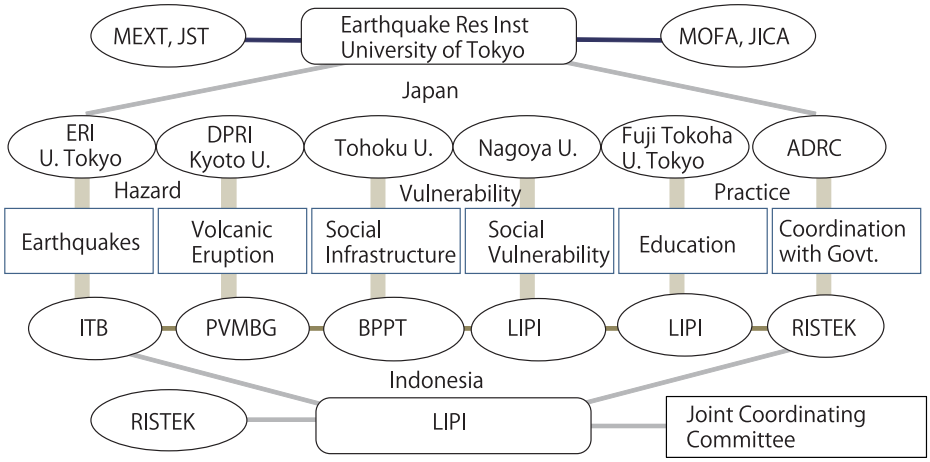

Fig. 2. Overall structure of the project, with the leading agencies for each group.

most recent event about 5-3 ka before the present) from field surveys including trenching surveys. This group also studies the Sumatra fault around Lake Singkarak.

G1-2: Study of historical earthquakes based on tsunami deposits and coastal geology

For the paleoseismological studies of interplate earthquakes, this subgroup conducts surveys on corals around the islands of Mentawai and Simeule and on tsunami deposits on Sumatra. The living corals record past environments, including sea level changes associated with past earthquakes, in the last few hundred years. The group has found, along the Sunda trench, traces of large tsunamis that occurred from about a few hundred to a thousand years ago.

G1-3: Crustal deformation monitoring using space geodesy and gravity

In order to monitor current crustal activities, this subgroup conducts GPS surveys on Java (Cimandiri-Lembang-Baribis faults) and northern Sumatra (Sumatra fault), gravity measurements around Jakarta and Bandung, and analysis of InSAR data for the Padang earthquake (September 2009) and LUSI mud volcano on Java. The GPS measurements show the current slip rate (6 mm/year) and locking depth (3 km) of the Lembang fault [2].

G1-4: Study to predict strong ground motion

This subgroup aims to predict strong motion that a future earthquake may cause around the Bandung Basin. They first validated the method using data from the 2006 Yogyakarta earthquake. The subsurface structure of the Bandung Basin was estimated from microtremor surveys at 30 points. They then predicted strong motion in the Bandung Basin from a characterized earthquake source model on the Lembang fault.

G1-5: Investigation of submarine active faults

This subgroup conducts marine surveys to identify submarine active faults in the source region of the 2004 Sumatra-Andaman earthquake. They have made detailed geomorphological maps of the seafloor and acquired MCS seismic profiles to identify possible causative faults. They have also analyzed piston cores to identify turbidites that were possibly formed during past offshore earthquakes. The estimated recurrence interval of past earthquakes has been about 330 years over the last 7500 years.

G1-6: Prediction of tsunami using numerical simulations

In order to predict tsunami inundation from future earthquakes, this subgroup conducts detailed coastal bathymetric surveys and land topographic surveys that include buildings in Pelabuhan Ratu, Pangandaran and Cilacap on the southern coast of Java. Using these data, they make tsunami numerical simulations from possible scenario earthquakes [3]. They have also done preliminary mapping of coral boulders transported by the tsunami from the 1883 Krakatau eruption.

3.2. Short-Term and Long-Term Predictions of Volcanic Eruptions and Development of a Method for Their Evaluation (Group 2)

Group 2 conducts research into short-term and medium- to long-term predictions of volcanic eruptions based on observations of the Semeru and Guntur volcanoes, investigation into huge volcanic eruptions in the past, and research into advancing the evaluation methods of volcanic activities including the recent eruptions of the Sinabung and Merapi volcanoes [4, 5].

G2-1: Mechanism of volcanic explosion and short-term prediction

This subgroup has installed three tilt meters on the Semeru volcano, which erupts very frequently – once every in tens of minutes. This group has detected precursory tilt

changes proportional to eruption size, which are important observational data to understand the eruption mechanism and for short-term prediction [4].

G2-2: Long and mid-term prediction of volcanic eruption and tectonics

This subgroup has installed seismic and GPS instruments around the Guntur volcano, and evaluates the relation between regional tectonics and volcanic activity. Active seismic activity occurred around Guntur volcano in 2011 following inflation detected by GPS instruments, and the seismic activity was interpreted as associated with volcanic activities. GPS monitoring has been done in the Sinabung volcano (Sumatra) and Merapi volcano (Java), both of which erupted in 2010 [4].

G2-3: Geological evaluation of frequency and process of caldera-forming eruption

This subgroup conducts geological surveys on Bali to date and clarify large caldera-forming eruptions. The group has found pyroclastic flow deposits and plinian pumice fall deposits from the Batur, Bratan, and Agung volcanoes; these deposits reflect the activities of these volcanoes over the last 20 ka. They have also conducted topography analysis and K-Ar dating to estimate the activities in the older dates.

G2-4: Proposal of evaluation method of volcanic activity

This subgroup studies evaluation methods, with case studies of the evaluation and warning procedure for the Kelud crisis in 2007. In addition, they have collaboratively evaluated the eruption potential for the ongoing activity in the Sinabung and Merapi volcanoes, both of which erupted in 2010 [4, 5].

3.3. Establishment of Social Infrastructure Based on Engineering Developments (Group 3)

Group 3 conducts engineering research and investigations in areas such as the effective use of tsunami hazard maps, the reduction of tsunami damage by the practical use of beach vegetation, the reduction of liquefaction disasters, introduction of technologies and systems to calculate design ground motions for scenario earthquakes, and strengthen buildings against earthquakes [6].

G3-1: Effective use of tsunami hazard maps

This subgroup targets Padang, where a large earthquake/tsunami is anticipated in the future [6]. Because several tsunami hazard maps have been made for Padang, their evaluation, improvement, effective use, and coordination with local government have been discussed. Many tsunami evacuation buildings were damaged by the 2009 Padang earthquake; thus, possible tsunami evacuation places have been newly selected.

G3-2: Reduction of tsunami damage due to the practical use of vegetation

This subgroup studies tsunami forests, which are effective in reducing the force of tsunamis on coastal structures. They conduct flume experiments at the BPPT experimental station in Yogyakarta, in addition to theoretical and numerical studies. They also conduct field tests at Pariaman on Sumatra, with *Casuarina* as a test tree species, and propose guidelines for the tree's practical use.

G3-3: Technology development for mitigating hazards due to liquefaction

This subgroup studies liquefaction potential in Yogyakarta and Padang. They have carried out microtremor measurements at numerous locations in Bantul (Yogyakarta) and Padang, done geotechnical drilling, and studied soil properties. These results are compiled as liquefaction potential maps. They have also studied building and liquefaction damage from the 2009 Padang earthquake.

G3-4: Investigation of design ground motion and implementation of earthquake-resistant housing by both the technological and social approaches

This subgroup studies design ground motion by calculating probabilistic ground acceleration and response spectra at selected cities. They have conducted microtremor measurements to study subsurface structure in Padang and done strong-motion observations in Bandung. They have also introduced at various locations in Indonesia a feasible and economical retrofit method and its promotion systems for vulnerable masonry houses by using polypropylene band.

3.4. Mitigation of Social Vulnerability Against Geohazards (Group 4)

Group 4 conducts humanities and social sciences research into disaster countermeasures based on communities, disaster prevention and reconstruction concepts which fit with regional cultures, reconstruction of lifelines and industries, and warning information dissemination [7, 8]. Their research results will be soon published as a book entitled "Community Approach to Disaster: Aceh, Yogyakarta, and Kelud Volcanoes, Indonesia."

G4-1: Strengthening of community-based disaster preparedness mechanism

This subgroup studies social vulnerability through sociological, legal, and human-geographical approaches [7]. It conducted comparative studies in Aceh after the 2004 tsunami and in Bantul after the 2006 Yogyakarta earthquake by carrying out questionnaire and interview surveys to understand the roles of social capital and community in the situations of emergency response and post-disaster reconstruction.

G4-2: Investigation of community-based disaster prevention and cultural-background-based restoration

This subgroup takes political and cultural anthropological approaches to understand local knowledge and disaster management [8]. It has constructed disaster management area-informatics database based on newspaper and other articles on the 2009 West Java and Padang earthquakes.

G4-3: Development of long-term recovery framework from natural disasters

This subgroup takes a social engineering approach to the study of the long-term recovery of lifelines, industry and individual life. It conducts comparative studies on lifeline recovery from the 1995 Kobe, 2004 Aceh, and 2009 Padang earthquakes, and it has done a detailed survey of waterline recovery and the use of tap water and well water in Banda Aceh.

G4-4: Warning dissemination and residents' psychological processes during natural disasters

This subgroup takes a socio-psychological approach to the study of people's reactions to disaster warnings. It selected the 2007 Kelud volcano crisis for a case study. Many interviews of various stakeholders and a quantitative mass-survey were conducted in order to examine the information dissemination process.

3.5. Disaster Education Promotion and Disaster Consciousness Raising (Group 5)

Group 5 develops and implements teaching materials and methods for schools and residents, collects and hands down disaster lessons through interviews and drawing pictures, and utilizes the Internet for disaster prevention education [9, 10]. This group has held many workshops in Banda Aceh, inviting many school teachers from the region.

G5-1: Development of effective disaster education programs at schools, effective disaster consciousnessraising programs, and collaboration with local governments and teachers

This subgroup conducts education programs in schools, using model lectures, tsunami memorial poles and teacher training. It also educates the citizenry through town watch programs and develops guidebooks and dynamic simulations of tsunami inundation and evacuation [10].

G5-2 Collection and transfer of disaster lessons

This subgroup collects disaster experiences and produces education material based on actual stories and pictures. It has produced a book on the 2004 tsunami and conducted model lectures in places such as Yogyakarta. It has also interviewed survivors of the 2010 Mentawai tsunami and drawn pictures based on their recollections.

Table 1. Number of visits from both countries supported by this project.

Fiscal Year (April-March)	Japan to Indonesia		Indonesia to Japan		
	Persons	Days	Persons	Days	Students
2009	90	905	14	187	2
2010	100	959	56	558	2
2011 until January 2012	87	751	23	216	2

G5-3: Development and testing of disaster education materials on the Internet

This subgroup develops and implements disaster education materials using an Internet-based distance education system. Several workshops held in Bandung, Banda Aceh, and Jakarta have been broadcast to a studio in Tokyo and other universities in Indonesia and other countries. The group also uses the Internet to disseminate their archive of disaster lectures.

3.6. Application of the Research and Establishment of Collaboration Mechanism Between Researchers and the Government Officials (Group 6)

Group 6 aims to construct a system for applying research results of the project to policy making by building synergies among universities, research institutes, and the government [11, 12]. Outreach from this project includes newsletters (in Indonesian and English), the TV program "IPTEK Talk" and radio programs. For the institutional aspect, a Joint Coordinating Committee (JCC) was established. This committee consists of representatives of Indonesian government agencies related to disaster prevention. This committee has been conducting discussions and giving advice on systems and organizations to utilize research results to develop policies.

4. Project Promotion

4.1. Support Offices and Researcher Exchanges

In order to support this project, a secretariat office with a support staff was established in the International Office of the Earthquake Research Institute of the University of Tokyo. The project office is located in the LIPI Coremap building, and two JICA staff members have started their activities with two local staff members. They meet regularly with LIPI staff to exchange information on this project. They also provide logistic support for researchers from each country to visit the other.

The numbers of mutual visits are listed in **Table 1**. It should be noted that, in addition to mutual visits of researchers, the project also supports, for the purpose of capacity building, Indonesian graduate students to study in Japan.

Fig. 3. Project members observed the tsunami evacuation drill at the Tsunami and Disaster Mitigation Research Center in Banda Aceh during the Indian Ocean Wave on October 14, 2009.

Fig. 4. Tsunami evacuation building near the port of Sendai, which was damaged during the 2011 Tohoku tsunami. The project leaders visited the location on May 29, 2011.

4.2. JCC Meetings and Project Workshops

In 2009, the first group leader meeting and JCC meeting were held in Jakarta on April 20; the kick-off workshop was then held in Bandung on April 21. Twenty-seven people, including 16 from this project, participated in the JCC meeting. The workshop in Bandung was connected to Tokyo and Banda Aceh through the Internet, and 51 participants from both Japan and Indonesia attended through that connection. Research plans of each subgroup were presented.

The first international workshop was held in Banda Aceh, October 11-13, 2009. About 80 people from Indonesia, Japan, Germany and the Philippines participated. Presentations from each subgroup were made, and cross-disciplinary discussion on this project ensued. The workshop was followed by observation of Indian Ocean Wave, a tsunami warning information transmission drill for all Indian Ocean countries. The participants observed the transmission process of tsunami warning messages from BMKG to provincial governments, then to district and sub-district communities, and finally the evacuation drills by the local residents (**Fig. 3**).

In 2010, the second JCC meeting was held in Jakarta on March 22, and the activities of the first year and plan for the second year were reported. On May 28, at the Japan Geoscience Union (JpGU) meeting in Chiba, Japan, there was an international session entitled "Multi-Disciplinary Studies on Natural Hazards in Asia," and about 20 papers from this project were presented. Following the JpGU meeting, there was a meeting of group leaders.

The second annual workshop was held from November 22-25, 2010 in Kobe, Japan. There were 84 participants in total, with 36 from Indonesia. In addition to the project workshop, there was an open session which included presentations on disaster management in Bantul regency, West Sumatra province, and Hyogo prefecture, Japan. A study trip to the Nojima fault museum and E-defense, the large 3-dimensional shaking table facility, was conducted.

In 2011, the group leader and JCC meetings were held on May 6. They were originally scheduled in March but were postponed because of the Tohoku earthquake and tsunami on March 11. On May 27, another international session was held at the JpGU meeting, and about 20 papers were presented from the project. There was another group leader meeting, and a visit was made to Sendai, the area affected by the Tohoku earthquake and tsunami, to learn from this disaster (**Fig. 4**). The third workshop was held October 27-29, 2011, in Jakarta, to coincide with Indonesia Disaster Preparedness, Response, and Recovery Exhibition & Conference (IDEC) 2011. On the first day, the project joined the Conference and made three presentations at the Disaster Management and Climate Change Conference which was organized by the Coordinating Ministry for People's Welfare. A total of 219 people participated, including 37 from our project. On the second and third days, in addition to the activity reports from all subgroups, there was discussion on "Science to Society." Based on the discussion, the participants (about 70, including 10 from outside the project) made recommendations (see Section 5).

4.3. Cross-Disciplinary Studies

On July 12-14, 2010 in Bandung, we held a topical workshop on Geodynamic and Disaster Mitigation of West Java. There were 88 participants in total, not only from our project but also from the US, Australia, and Singapore. We exchanged information on various research results and discussed how to improve hazard assessments in West Java, particularly around the Bandung basin. About half of the presentations were on the Lembang fault. Paleoseismological studies show that past motion was a normal fault-type motion, while the GPS measurements show that the current motion is right-lateral strike-slip. Recent probabilistic seismic hazard maps of

Fig. 5. Trenching site on Lembang fault. The Bandung workshop participants visited this site on July 13, 1010.

Fig. 6. Interviewing survivors of the Mentawai earthquake tsunami, in Sabeu Gunggung on North Pagai island on November 8, 2010.

Indonesia include this fault, but the effect of subsurface structure beneath the Bandung Basin is not taken into account. There was also a field trip to the Lembang fault trench site (**Fig. 5**) and the BMKG seismic station.

Since the current project started in 2009, there have been many earthquakes, tsunamis, and volcanic hazards in Indonesia. In September 2009, there were earthquakes off west Java and near Pandang. The Sinabung volcano started erupting in 2009 after lying dormant for several centuries. The Merapi volcano erupted in 2010, causing pyroclastic flows. In addition, the Mentawai earthquake in October 2010 generated tsunamis. We conducted emergency and multi-disciplinary surveys of the above earthquakes, tsunami, and volcanic activities. We present the 2010 Mentawai tsunami survey as an example.

A multi-disciplinary field survey team, consisting of members from Groups 1, 3, and 6, was dispatched in November, about two weeks after the tsunami. They measured tsunami heights ranging from 2.5 to 9.3 m at 8 locations on North and South Pagai Islands and tsunami inundation of more than 300 m at three locations. They also collected samples of tsunami deposits. Interviews of local residents (**Fig. 6**) indicate that they felt ground shaking weaker than those during the 2007 Bengkulu earthquakes (M8.5 and 7.9) or the 2009 Padang (M7.5) earthquake. The 2010 Mentawai earthquake was a tsunami earthquake, and it generated a larger tsunami than would be expected from the magnitude of its seismic wave (M7.2 according to BMKG). The official tsunami warning from BMKG reached the Mentawai regency office but did not reach coastal communities because of a lack of communication tools. However, some coastal residents were watching TV and saw the tsunami warning as an on-screen crawler. In some communities such as Sabeu Gunggung or Muntei, nearly half of the villagers lost their lives, while there were only a few fatalities in others such as Maonai or Tumali. Tsunami education, repeated drills, and proximity to high ground seem to make a dramatic difference.

5. Conclusions

The current project is to terminate in May 2012, but we hope to continue collaboration between Japan and Indonesia on natural hazards and disaster reduction. In particular, geophysical monitoring such as seismic observation and GPS measurements for active faults and volcanoes need to be kept for a long time. We also realize that capacity building, particularly for young graduate students is very important in both countries.

To promote our multi-institutional and multi-disciplinary project, we set up the Joint Coordinating Committee by inviting members from all the ministries and agencies. We hope to maintain the Committee as a council organization consisting of disaster reduction researchers and government representatives involved in natural disasters and disaster prevention in Indonesia. Therefore, at the final workshop held in October 2011, we made the following recommendations.

1 The Joint Coordination Committee (JCC), established to monitor the progress of the SATREPS project and composed of all disaster-related institutions in Indonesia, namely, RISTEK, LIPI, DIKNAS, ESDM, DKP, KOMINFO, PU, DEPDAGRI, BPPT, and BNPB, can be promoted to Indonesian key stakeholder as a platform to pursue such objectives.

2 The function of the JCC should be continued or expanded in any format to continue the collaboration between Indonesia and Japan for research activities in relevant fields and enhance the use of research outcomes for policy development aimed at natural disaster reduction in Indonesia.

3 BNPB, the National Disaster Management Agency of the Government of Indonesia responsible for overall disaster management, needs to take the lead and thus should be further involved in such activities.

Hence, such a request will be made to BNPB so as to discuss how international collaboration between Indonesia and Japan in these fields should be continued and further enhanced along this line.

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• K. Satake, "Tsunamis, in Treatise on Geophysics," Vol.4, Elsevier, pp. 483-511, 2007.
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Selected Publications:

• Satish, Singh C., N. Hananto, M. Mukti, H.Permana, Y. Djajadihardja, and H. Harjono, "Frontal rupture and large tsunami during the 25 th October Pagai Earthquake," SW Sumatra., Geophys. Res. Letters , Vol.38, L16313, 6 pp., doi:10.1029/ 2011GL048935, 2011.
• Satish C. Singh, N. Hananto, M. Mukti, D. P. Robinson, S. Das, A. Chauhan, H. Carton, B. Gratacos, S. Midnet, Y. Djajadihardja, and H. Harjono, "Discovery of a deep subducted seamont beneath the Sumatra aseismic forarc mantel," Nature Geosciences. Nature Geoscience, Vol.4, Issue 5, pp. 308-311, DOI:10.10.38/NGEO1, 2011.

Academic Societies & Scientific Organizations:

• Indonesian Association of Geophysicists (HAGI)
• Indonesian Association of Geologists (IAGI)