

Hazard Risk Management and Mitigation System of Earthquake and Tsunami on Disaster-Prone Area

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Abstract— Earthquake and Tsunami are one of the biggest disasters dealing with countries located in disaster-prone areas. A risk management and mitigation system are crucial for those countries to reduce the risk of disasters. Indonesia already started to pay attention to the disaster mitigation system since the tsunami that occurred in Aceh in 2004. Various initiatives to reduce the risk of the disaster have been started, the focus is by Increasing knowledge and raising awareness of hazards and the skills to manage disasters. By then, the mitigation system still not capable enough to reduce the risk of the disaster. This can be seen after the tsunami that occurred in Aceh, Indonesia faced a lot of earthquake and tsunami disasters until 2018 and caused severe damage in each incident. On the other hand, Japan's management and mitigation system facing the same disasters (earthquake and tsunami) had been proven most successful since the Great Hanshin-Awaji Earthquake in 1995. This research aims to analyze and compare both Japan and Indonesia's strategies in disaster management and to find out the risk management and mitigation system that can reduce the risk of the earthquake and tsunami disaster. The result found out there is an application called “Disaster Reduction Class” developed by Prof. Akiyoshi Takagi that needs to be implied in Indonesia to reduce the risk of earthquake and tsunami disaster.

Keywords— earthquake and tsunami; disaster mitigation system; disaster risk reduction; damage.

I. INTRODUCTION

Indonesia is known as a disaster-prone country because of this country, as shown in Figure 1, surrounded by the Pacific Ring of Fire and is above three continental plate collisions, namely Indo-Australia from the south, Eurasia from the north, and the Pacific from the east.

This geographical condition makes this country never escape from natural disasters such as earthquakes and tsunami. According to the world risk report, Indonesia is ranked 34 out of 171 countries in terms of risks to various hazards. This report points out that Indonesia had a "very high" risk and exposure, "high" vulnerability and susceptibility, and a lack of coping and adaptive capacities [1]. Most Indonesian provinces and their coastal areas were identified as "disaster-high risk." However, more than half of the total population lives in and is dependent on these areas [2]. As stated on the UNISDR Global Assessment Report [3], disaster risk reduction (DRR) is the policy objective of anticipating and reducing risk. Although often used interchangeably with DRR, disaster risk management (DRM) can be thought of as the implementation of DRR. Disaster Risk Reduction (DRR) aims to reduce the damage caused by

natural hazards like earthquakes, floods, droughts, and cyclones, through an ethic of prevention [3]. UNISDR [3] adds that disaster risk management involves activities related to prevention, mitigation, transfer, and preparedness.

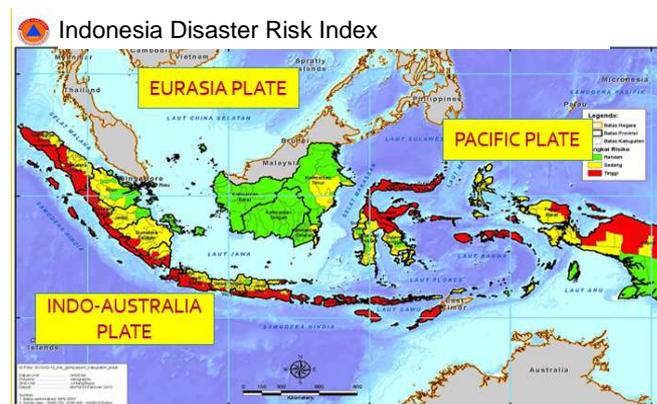


Fig. 1 “Disaster Reduction Class,” Main Display [2]

Preparedness in Indonesian Law No. 24 of 2007 [4] concerning Disaster Management is a series of activities carried out to anticipate disasters through organizing as well

as through appropriate and efficient steps. LIPI-UNESCO/ISDR [5] conducted the development of community preparedness frameworks to anticipate natural disasters that begin with a study of critical factors that have a significant influence on the community in dealing with natural disasters. In that study, there are five critical factors of preparedness to anticipate natural disasters, especially earthquakes and tsunamis, which become the parameters in the assessment framework; the parameters are below:

- Knowledge and attitude towards disaster risk. Knowledge is the main key to preparedness; the knowledge possessed can influence the attitudes and concerns of the community to be ready and alert in dealing with disasters, especially people who live in disaster-prone areas.
- Policies and guidelines. The natural disaster preparedness policy is very important and is a concrete effort to carry out disaster preparedness activities.
- Plans for disaster emergency activities. The plan is an integral part of preparedness, especially concerning evacuation and rescue, so that victims can be minimized.
- Disaster warning system. This system includes warning signs and information distribution about disaster occurrence.
- The ability to mobilize resources. The availability of resources, both human resources, as well as funding, facilities, and essential infrastructure for emergency activities are potentials that can support or otherwise become obstacles in disaster preparedness.

Realizing the high risk of disasters, the people of Indonesia must be ready and prepared to respond and accept the responsibility for any disaster, especially to earthquake and tsunami. It started with how to handle the disaster victims, how to re-build the building after the disaster, how to educate people that living in disaster-prone areas, and the more important is how to manage an excellent mitigation system that can reduce the risk of the disaster. The importance of preparedness has been stated in UU no. 24/2007 and Government Regulation Number 21 in 2008 [4]. Since the tsunami that occurred in Aceh in 2004, the Indonesian government and the Indonesian National Board for Disaster Management (BNPB) started to take various initiatives to reduce the risk of the disaster. Increasing knowledge and raising awareness of hazards and the skills to manage emergencies become the focus of disaster risk reduction [6].

By then, the mitigation system is still not capable enough to reduce the risk of the disaster. Padang City, as located on the west coast of Sumatera Island, suffered a devastating earthquake on September 30, 2009, caused thousands of victims, buildings, and public facilities were destroyed during the incident [7]. Then, in 2018 disaster occurred repeatedly in Indonesia, starting from the earthquake that occurred in Lombok on July 29th, 2018 and August 5, 2018, earthquake followed by tsunami and liquefaction in Palu and Donggala on September 28th, 2018, and the last is a tsunami that occurred without warning in Selat Sunda on December 22nd, 2018. Disasters in 2018 caused severe damage, where

thousands of people become the victims, and a lot of buildings and public facilities also destroyed. It shows that the people of Indonesia still not ready to face the disaster. The management and mitigation system still need to be improved.

As a comparison, the case of Japan, despite highest disaster preparedness by the Japanese government, on March 11, 2011, northeastern part of Japan has been severely devastated by magnitude 9 earthquake followed by tsunami (called Tohoku Earthquake) which killed 15,897 people, 2,532 people missing, 129,391 houses in total damage, 265,096 houses in half damage, and properties worth of ¥316,900 billion. The severity of the disaster was beyond imagination, which caused significant damage to precious lives and properties. The Japanese experience of disaster management and mitigation and community involvement in the Great Hanshin-Awaji Earthquake had been proven most successful [8]–[10]. In Japan itself, self-help and mutual-help become the focus as one of the efforts to reduce the risk of disaster. Professor Akiyoshi Takagi from Gifu University Japan developed an application named “Disaster Reduction Class” [11]. This application consists of several questions that help the people of Japan to do self-help and mutual-help to protect themselves from disaster. Besides, this application helps not only for the people who use it personally but also helps the government and people who are experienced in disaster prevention to analyze how ready a community or the people of a country to face the disasters. This research highlights the comparison between Japanese and Indonesian disaster management by using the “Disaster Reduction Class” application as one of the managements and mitigation systems that can reduce the risk of the earthquake and tsunami disaster [12].

II. MATERIALS AND METHODS

The method that used in this research is descriptive-explanative. This research aims to find out the risk management and mitigation system that can reduce the risk of the earthquake and tsunami disaster. To find out the risk management and mitigation system [13], [14], this research compared both Andalas University students and Gifu University students' awareness to face disaster by using the application “Disaster Reduction Class” which was developed by Takagi and Azuma [11]. The respondents from each university were chosen randomly. The use of this application makes the people who try this application understand and practice. People can identify ‘Thing that they do not do’ and ‘how can they do it’ to protect themselves from disasters.

The research by Takagi and Azuma [11] was conducted at 2017 in World Bosai Forum that tested this application to some student from 2 different schools, office employee, and official staff shows that this application can promote the preparedness for disaster in the family of members of organizations, grasp the problems as an organization by comprehending their responses, and discuss future efforts. The application can also promote the preparedness for disaster in the students’ families, including foreigners, and help to understand terms regarding disaster prevention.

Disaster Reduction Class is an application that was developed by Prof. Akiyoshi Takagi from Gifu University, Japan [9], [15]. This application makes the people who use

this application understand and practice. People can know “What did not they do?” and “How can they do it?” to protect themselves from disasters. The application consists of several questions that guide people to do self-help and mutual-help facing the disaster by using the checklist, then recognize their problems. The numbers of the question are based on what level are chosen. This application has two versions: website versions and smartphone versions. In smartphone versions, people can take a regular “Test” on a set day every year, and also, if the user chooses "Try now," then register how long to take the practice, the application notifies the user on deadline and leads to putting into practice. Figure 2 shows the smartphone versions of the “Disaster Reduction Class” application.



Fig. 2 Smartphone version of the “Disaster Reduction Class” application.



Fig. 3 “Disaster Reduction Class” website version main display.

In this application, there are two levels, which are the Basic Course and Intermediate Course. Before the user takes a test in this application, they should choose what level they want to take—both in the smartphone or website version show this level option in the main display. Figure 3 shows the main display of the web versions of the application.

Basic Course consists of 20 questions targeting adults from fifth-grade elementary school students, and Intermediate Course consists of 30 questions, including 20 questions of beginner course and additional ten questions assumed for community leaders and managers of disaster prevention and reduction in communities and companies.

There are three options, “Yes,” “Maybe,” and “No” from each question. Fig.4 shows the display of each option.

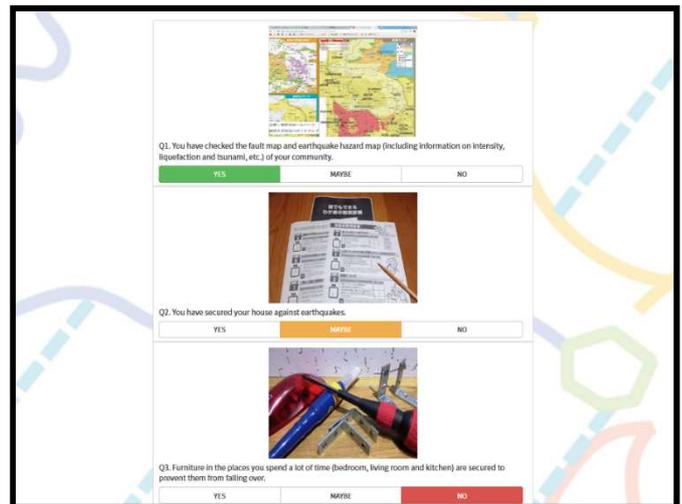


Fig. 4 “Disaster Reduction Class” website version questions and options.

At the end of the test, this application showed the score and some explanations of each answered question. This score helped the user of this application, knowing how ready they are to face a disaster. Figure 5 shows the score display.

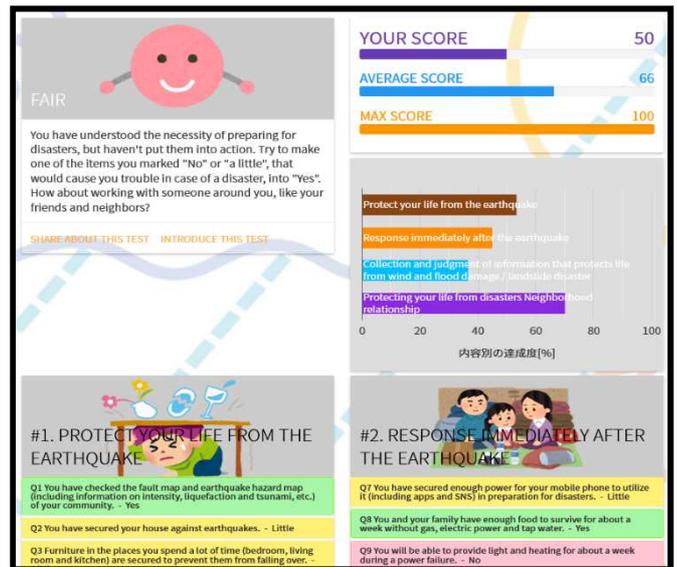


Fig. 5 “Disaster Reduction Class” website version score display.

This research analyzes and compares the data from University students of Andalas University and Gifu University on how many students choose “yes,” “maybe,” and “no” and check how this application can affect the students' behavior to face the earthquake and tsunami disaster according to the 20 questions in basic course level.

III. RESULTS AND DISCUSSION

This research collected data from University students of each country by using the following 20 questions from the Basic course level. The questions show in Table I.

TABLE I
QUESTIONS OF BASIC COURSE LEVEL

Protect your life from the earthquake	
Q1.	You have checked the fault map and earthquake hazard map (including information on intensity, liquefaction, and tsunami, etc.) of your community.
Q2.	You have secured your house against earthquakes.
Q3.	Furniture in the places you spend a lot of time (bedroom, living room, and kitchen) are secured to prevent them from falling over.
Q4.	You and your family don't sleep in places where heavy furniture, shelves, broken lights, or glasses may fall on you in case of an earthquake.
Q5.	You can protect your body, especially head, at the moment of the quake or urgent earthquake alarm.
Q6.	You can evacuate to higher ground without hesitation in case of a severe earthquake while visiting or living close to the sea, even if nobody else does.
Response immediately after the earthquake	
Q7.	You have secured enough power for your mobile phone to utilize it (including apps and SNS) in preparation for disasters.
Q8.	You and your family have enough food to survive for about a week without gas, electric power, and tap water.
Q9.	You will be able to provide light and heating for about a week during a power failure.
Q10.	You and your family have discussed what you should do after an earthquake, how to contact each other in case you are in separate places when the earthquake strikes, for example.
Collection and judgment of information that protects life from wind and flood damage/landslide disaster	
Q11.	You have looked at the hazard map of your community to check dangerous places in case of storm, flood, and landslide disaster.
Q12.	You have had a look at yourself at the dangerous places in case of storm, flood, and landslide disaster in your community.
Q13.	You have understood types of evacuation, horizontal evacuation, vertical evacuation, and staying at the safest place in your house, depending on the danger of the storm, flood, and landslide disasters. You have also decided where and how to take temporary shelter.
Q14.	You have actively gathered the necessary information, such as rainfall and river level, by yourself to decide whether you should evacuate or not regardless of the information provided by the (local) government.
Q15.	You are prepared to be "positively isolated" when it seems more dangerous to move to the temporary shelter in case of flood and heavy rain.
Q16.	You have discussed what to do in the time of flood, storm, and landslide disaster with your family.
Protecting your life from disasters Neighborhood relationship	
Q17.	You usually take part in community activities such as neighborhood groups, children's groups, cleaning projects, and athletic meets.
Q18.	You have discussed what to do in preparation for natural disasters (to prevent and mitigate disasters), with your neighbor or in your community.
Q19.	You have built a good relationship with your neighbors and understood who needs help in the time of evacuation.
Q20.	You have willingly taken part in disaster drills in your community.

By using the checklist of every question in the basic course, as shown in table 1, this research collected the data on how many students choose "yes," "maybe," and "no" of

each question. The collected data shows in Figure 6 and Figure 7 below.

Based on both data, the most "yes" chosen by Andalas university students is on Question number 5 "You can protect your body, especially head, now of the quake or urgent earthquake alarm." It means that most of the Andalas University students already know how to protect their bodies in case of an earthquake or urgent alarm.

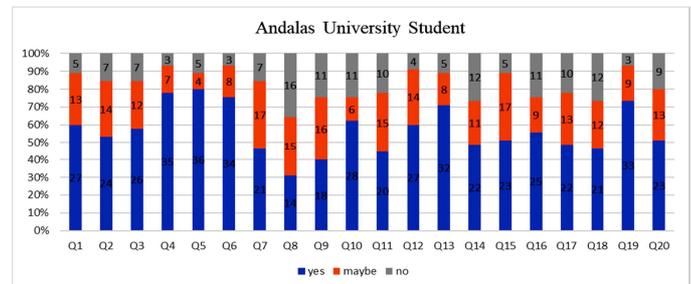


Fig. 6 Data of 45 participants from Andalas University Students.

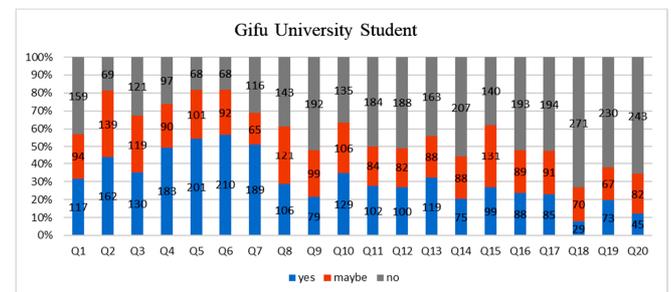


Fig. 7 Data of 370 participants from Gifu University Students.

On the other hand, the most "yes" that chosen by Gifu university students is in question number 6 "You can evacuate to higher ground without hesitation in case of a severe earthquake while visiting or living close to the sea, even if nobody else does." That means most Gifu university students are more prepared to evacuate themselves to the highest place in case of a severe earthquake while visiting or living close to the sea.

The most "maybe" chosen by Andalas University students are in question number 7 "You have secured enough power for your mobile phone to utilize it (including apps and SNS) in preparation for disasters." The students of Andalas University still not sure and prepared if they have enough power for their mobile phone in case of disaster happened. Gifu university students choose the most "maybe" in question number 2 "You have secured your house against earthquakes." They are still not sure if their houses secure against the earthquake.

The most "no" chosen by Andalas University students are in question number 8 "You and your family have enough food to survive for about a week without gas, electric power, and tap water." Most of the Andalas University students are not preparing themselves and family for food to survive at least for a week in the condition where there is no gas and electrical power after the disaster. On the other hand, the most "no" that chosen by Gifu university students are in question number 18 "You have discussed what to do in preparation for natural disasters (to prevent and mitigate disasters), with your neighbor or in your community". Most

of the students have not discussed with their neighbors and community about what to do in preparation for natural disasters (to prevent and mitigate disaster).

Figure 6 and Figure 7 shows that Andalas university students seem to be more prepared than a student from Gifu university students. This is because the sample is chosen based on a random sampling method that is caused by the number of the participants seems to be unbalanced and also it can be influenced by knowledge factors where Andalas University students are mostly civil engineering students who already have disaster knowledge and experience related to their studies. In contrast, Gifu university students have a broader scope. [16] stated that good knowledge could be influenced by experience factors that influence someone to behave. Knowledge is information that is known or realized by someone who appears when someone uses his senses or intellect to recognize objects or events that have never been seen or felt before. Then, to find out the behavior of both university students according to Self-help and Mutual-help, that is the purpose of this application. Figure 8 and Figure 9 shows what questions both university students get the lowest “Yes” answer.

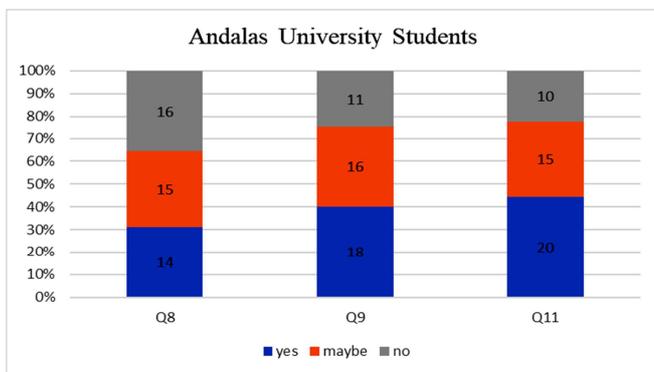


Fig. 8. Top 3 question with the lowest “Yes” chosen by Andalas University students

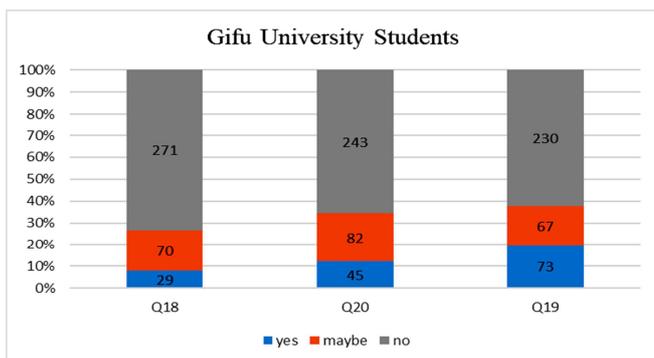


Fig.9. Top 3 question with the lowest “Yes” chosen by Gifu University students

The data from Figure 8 and Figure 9 shows that each student of both countries has different behavior and awareness in facing disaster. Where, Andalas University Students have the lowest “yes” answer mostly in questions that consist of self-help parameters (Q8, Q9, and Q11), while Gifu University students are mostly on questions that consist of the mutual-help parameter (Q18, Q20, and Q19). Both

university students from each country have a different problem, according to self-help and mutual help.

Self-Help itself demands that individuals first secure their own safety in the event of a disaster. Mutual-help then reflects their community participation until public institutions can help. According to a study about disaster reconstruction in Japan by Aota [1], the government’s concept of the so-called “new public commons” as the foundation of Japan’s disaster risk-reduction strategy with the following three main components: a) self-help, b) mutual assistance and c) support from the government or public-private partnerships. Social responsibility and mutual assistance are the tenets of Japan’s resilience in an era of uncertainty and disruption. Mutual assistance dynamics run on social capital that emanates from the trust, norms of reciprocity, and networks. [9] also stated that Specific efforts for disaster reduction require a combination of self-help, mutual assistance, and public assistance. Self-help makes each person, family, organization, or office, for example, should autonomously make decisions about their personal safety, which involves preparing oneself to cope with themselves and their own lives out of danger in case of disaster happened [9]. When it comes to decisions at that moment and specific guidelines for action, regular drills and simulations are effective, but in the end, every individual also needs an awareness that they would be on their own with no one else to depend on. Then, Harada (2012) also explained that for mutual assistance, the important is the formation and maintenance of tight networks based on regular information sharing and collaborative relationships such as neighborly cooperation in communities and tie-ups between organizations. This refers to verifying and supplementing one’s network of contacts through communicating with one’s neighbors and conducting regular evacuation drills. However, the behavior of each student from both universities according to their problem on self-help and mutual-help need to be improved.

Therefore, this application can help them to change their behavior and improve their awareness in case of the disaster happened, especially to earthquake and tsunami. Based on the data above, the author tried to analyze how much this application can affect the mindset of students towards self-help and mutual-help in disaster mitigation. The author has collected the improvement data from Andalas University students and Gifu University students. Students are asked to choose the questions they initially answered with “maybe” and “no” then change it to “yes” in case they want to improve their awareness. Figure 10 and Figure 11 show the improvement of Andalas University Students and Gifu University Students.

Figure 10 and Figure 11 show that Andalas University students get the excellent improvement in question number 8 (You and your family have enough food to survive for about a week without gas, electric power, and tap water.), in which they wanted to be more prepared for food at least for a week in the condition where there is no gas and electrical power after the disaster. Gifu University students get excellent improvement in question number 10 (You and your family have discussed what you should do after an earthquake, how to contact each other in case you are in separate places when the earthquake strikes, for example), where they wanted to

improve their family communication to discuss what should they do and how to contact each other after the earthquake.

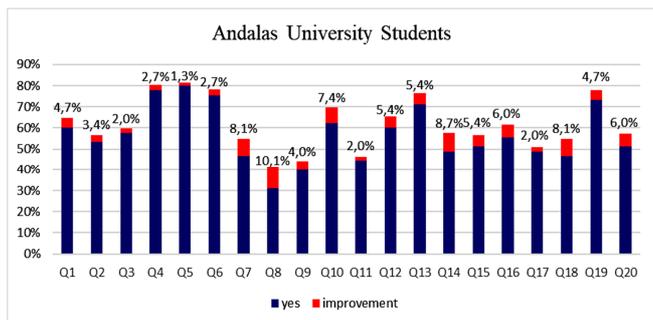


Fig. 10, Andalas University Students Improvement.

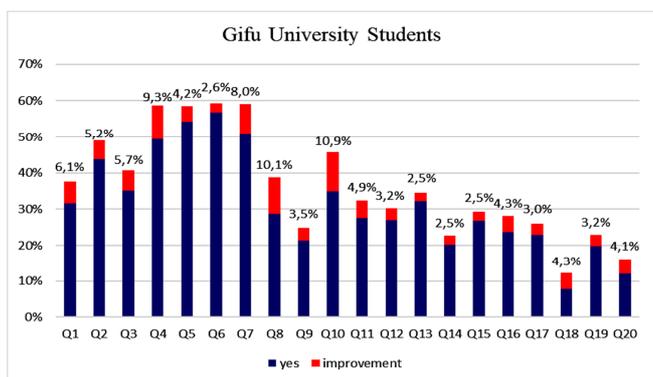


Fig. 11 Gifu University Students Improvement.

This improvement of both University students shows that the “Disaster Reduction Class” application can help the students to be more educated and prepared for disasters, especially in terms of self-help and mutual help to earthquake and tsunami.

IV. CONCLUSION

“Disaster Reduction Class” application shows that the students of Andalas University and Gifu University have different behavior in facing disasters, especially earthquakes and tsunami. However, this application can affect the awareness of both university students facing disasters. The improvement shows that the students have a desire to change to be more prepared to face disasters, especially earthquakes and tsunami. Self-help and mutual-help, which is the purpose of this application, can be an excellent way to reduce the risk of the disaster. People can educate themselves and improve their awareness of hazards. Therefore, this application helps not only for the people who use it personally but also helps the government and people who are experienced in disaster prevention to analyze how ready a community or the people of a country to face the

disasters and then can improve the management and mitigation system for emergencies.

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REFERENCES

- [1] Aota, R., Consideration of “new public commons” characteristics for disaster reconstruction. *Japan Social Innovation Journal*, 2(1), pp. 1–17, 2012.
- [2] BNPB. Data dan Informasi Bencana Indonesia. Jakarta, Indonesia: BNPB, 2014.
- [3] UNISDR, GAR. "Global Assessment Report on Disaster Risk Reduction, Making Development Sustainable: The Future of Disaster Risk Management." United Nations, Geneva (2015).
- [4] Indonesia, Republik. "Undang-Undang No. 24 Tahun 2007 tentang Penanggulangan Bencana." Lembaran Negara RI Tahun 68 (2007).
- [5] Hidayati, D., H. Permana, K. Pribadi, F. Ismail, K. Meyers, and A. Widayatun. Assessing and recognizing community preparedness in natural disasters in Indonesia. *Kajian Kesiapsiagaan Masyarakat Dalam Mengantisipasi Bencana Gempa Bumi dan Tsunami di Indonesia*. LIPI-UNESCO/ISDR, Indonesia, 2006.
- [6] Deny Hidayati. The Role of Social Capital in Enhancing Community Disaster Preparedness and Building Back Better in Recovery. *Journal of International Conference on Disaster Management (ICDM)* 2018.vol. 229
- [7] Dr. Priyanka Banerji, Ms. Nidhi Singh, Comparative Analysis of Disaster Management between Japan & India. *IOSR Journal of Business and Management (IOSR-JBM)* e-ISSN: 2278-487X, p-ISSN: 2319-7668. Volume 13, Issue 6 (Sep. - Oct. 2013), PP 62-74.
- [8] <http://gensaikyoushitsu.sakura.ne.jp/>
- [9] Harada, H., Social capital in disaster: From the great east Japan earthquake. *The Senshu Social Capital Review*, 3, pp. 5–21, 2012.
- [10] M.W. Beck, Ed., Coasts at Risk: An Assessment of Coastal Risks and the Role of Environmental Solutions. A joint publication of United Nations University - Institute for Environment and Human Security (UNU-EHS), The Nature Conservancy (TNC) and the Coastal Resources Center (CRC) at the University of Rhode Island Graduate School of Oceanography. 2014.
- [11] Takagi, A., and Azuma, Y. (2017) Web Application "Disaster Reduction Class" for facilitating understand and practice for disaster risk preparedness and reduction. *World Bosai Forum - IDRC Sendai* 2017
- [12] Z. Alhadi. Kesiapan Jalur dan Lokasi Evakuasi Publik Menghadapi Resiko Bencana Gempa Dan Tsunami Di Kota Padang (Studi Manajemen Bencana). *Humanus*, 13(1), 35-44 (2014)
- [13] Anantasari, E., Daly, M., Glassey, P., Grace, E., Coomer, M., & Woods, R. (2017). Disaster risk reduction (DRR) capacity and capability of local government in Indonesia. In *Disaster Risk Reduction in Indonesia* (pp. 127-155). Springer, Cham.
- [14] Davidson, Alistair, and Drew H. Webb. "Integrated hazard risk management and mitigation system." U.S. Patent 9,613,523, issued April 4, 2017.
- [15] Krausmann, Elisabeth, and Ana Maria Cruz. "Impact of the 11 March 2011, Great East Japan earthquake and tsunami on the chemical industry." *Natural Hazards* 67, no. 2 (2013): 811-828.
- [16] Deng, Y., Wang, M., & Yousefpour, R. (2017). How do people's perceptions and climatic disaster experiences influence their daily behaviors regarding adaptation to climate change?—A case study among young generations. *Science of the total environment*, 581, 840-847.