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Background to the Rapid Evacuation from the 2015 Eruption and Education for Disaster Prevention by Residents on Kuchinoerabujima Volcano

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Abstract

The 2014 Ontake eruption and the 2011 Great East Japan Earthquake resulted in some revision of government measures for disaster prevention. The role of residents in disaster prevention is increasing. The effectiveness fusing of tourism with disaster prevention education in the disaster prevention system is confirmed in some volcanic areas.

This paper focuses on the background to the rapid evacuation during the 2015 Kuchinoerabujima volcano eruption as a case study focusing on disaster prevention action and daily disaster awareness of volcanic activity. The case of the 2015 Kuchinoerabujima eruption shows that it is important to enhance relationships not only among experts, local government, residents, and the media but also among experts and non-expert residents who have an interest in volcanic activity.

In Kuchinoerabujima, based on the proven program of nature study abroad, the effectiveness of fusing tourism with disaster prevention education in the disaster prevention system is confirmed. Cooperation between tourism and disaster prevention is important for the safety of visitors and the safety and livelihoods of residents.

Keywords：Kuchinoerabujima volcano, disaster prevention education, tourism, migration policy.

1．Introduction

Kuchinoerabujima is an active volcano in Kyushu, Japan, with a length of about 13 km and an area of about 38 km^2 (Figure 1). The island can only be reached by boat. The residents are dependent mainly on fishing, agriculture, and seasonal tourism.

Geshi and Kobayashi, 2007 reported the history of Kuchinoerabujima volcano. It consists of a group of volcanoes with different activity levels and eruptive centers. The beginnings of this volcano are unknown; Gokyo volcano in the northern part of the island seems to have risen grown to the sea surface up to 500,000 years ago. Banyangamine volcano that constitutes the northwestern part of the island is about 200,000 years old. The central part of the island consists of Noike, Hachikubo, Furudake and Shindake volcanoes which have been active within about 15,000 years recently, and lava flow and explosive eruption have been repeated from the summit crater. The earliest recorded eruption in history was 1841ago; after that, eruptions have frequently recurred on Shindake. It was active from 1931 to 1934, and an eruption occurred on December 24, 1933. Pyroclasts from Shindake reached a distance of 2 km in the southeasterly direction, resulting in 34 victims. In the 1966 eruption, pyroclasts reached a distance of 3 km in the north-northeasterly direction. After that, some smaller eruptions occurred repeatedly. In 1980, an eruption occurred in the crack of the east side of Shindake. After that, an explosive eruption occurred on August 3, 2014.

On May 29, 2015, an eruption occurred at Mt. Shindake on Kuchinoerabujima, and an emergency warning (Level 5: Evacuate from the residential area) was announced for the first time in Japan. All residents on the island then evacuated to outside the island rapidly after the 2015 eruption. Another eruption with a total eruptive volume of 1×10^4 m^3 dense-rock equivalent (DRE), as estimated

from ash fall distribution, that occurred on August 3, 2014. Following this event, premonitory volcanic activities, including an increased discharge of volcanic gas, ground deformation, and positive volcanic earthquake activities, proceeded in a stepwise manner. The eruption column reached more than 9 km above the crater in the May eruption, and the pyroclastic flow covered more than 2 km near the coastline. The eruptive volume has been estimated at approximately 2 x 10^5 m^3 DRE, including the June 19 eruption, based on ash fall distribution.

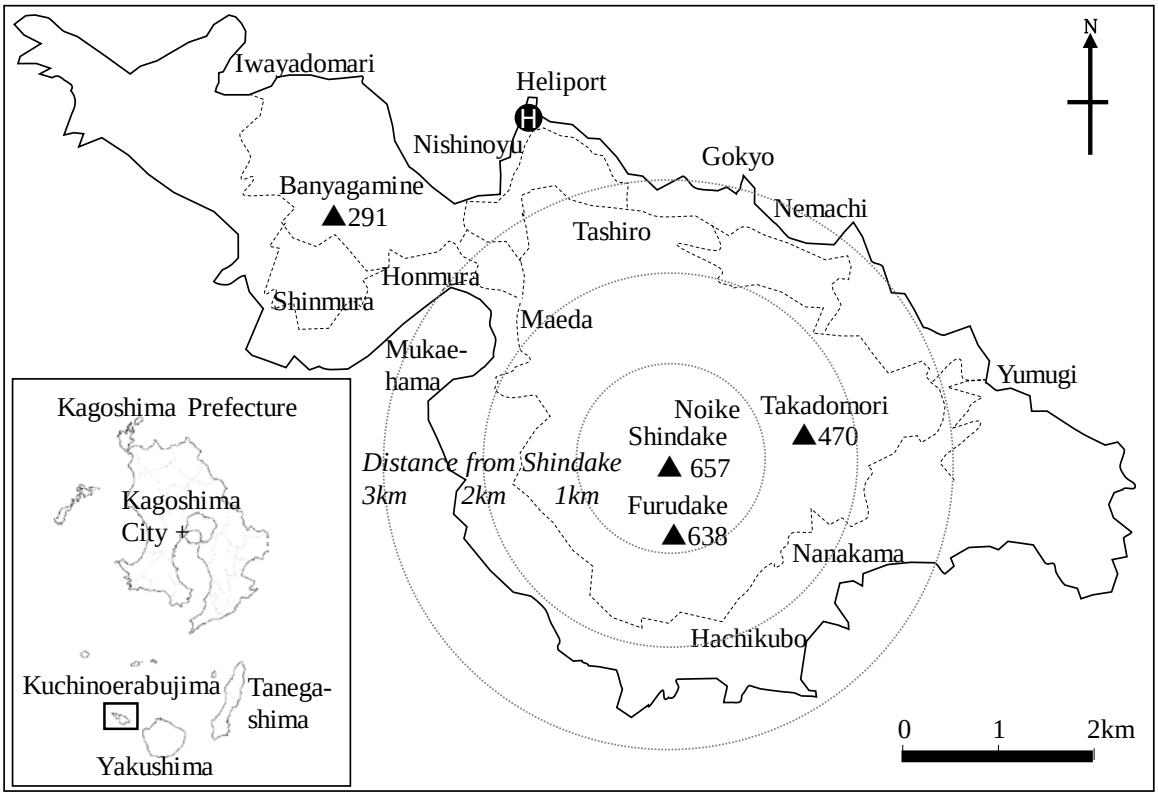

Figure 1 Map of Kuchinoerabujima volcano.

The Japan Central Government amended the Act on Special Measures for Active Volcanoes in September, 2015. A specific evacuation plan was developed, with provisions such as a requirement that customer facilities such as hotels and ropeways provide shelter and evacuation routes in municipalities with volcanoes (Cabinet Office, 2015).

Volcanic eruptions are characterized by a large spatiotemporal gap between the geological phenomenon and its consequent risk to human life. Volcanic disasters thus require quick decision-making under uncertain circumstances. The perception of residents living near the volcano depends on volcanic activity, and the dissemination of disaster information among local communities is left to the consideration of the volcanic disaster prevention council in each region, in accordance with their own code of conduct.

This paper focuses on the background to the rapid evacuation from the 2015 eruption of Kuchinoerabujima volcano, with the focus on disaster prevention through tourism. It presents case studies of disaster prevention action from daily life.

2. Relationship with Disaster Prevention

2.1. Volcanic Observation and Warning System of the JMA

The JMA (Japan Meteorological Agency), based on the Meteorological Service Act, made a presentation of monitoring and information of volcanic activity (Yamasato, 2003). Information for the protection of people's lives and bodies from disaster caused by a volcanic phenomenon, which has been defined in

the Act on Special Measures for Active Volcanoes, must be reported to the relevant prefectural governor. On November 21, 2007, the phenomena of earthquake and volcano were added to No. 115 of the law regarding the duty of the JMA to make forecasts and issue warnings. Along with this, since December 1, 2007, the volcanic activity level has been abolished, and an eruption warning level introduced. The eruption warning level is an index of five steps according to the situation of volcanic activity, as well as the index of "Action of disaster management agencies, residents, and climbers for disaster mitigation." This eruption warning level makes it possible to undertake disaster prevention, such as rapid intrusion regulation and evacuation operation by a pre-agreed range, and it is expected to lead to disaster risk reduction (Yamasato, 2013).

Due to the 2011 East Japan Great Earthquake disaster and the Kii Peninsula heavy rain disaster, the JMA launched the Emergency Warning System including volcanic activity on August 30, 2013. Emergency warnings are issued to alert people to the significant likelihood of catastrophes in association with natural phenomena of extraordinary magnitude, and call to “take action immediately to protect individuals in the best way you can” (JMA, 2014a).

Due to the 2014 Ontake eruption, the JMA had started issuing "Volcanic Information for Mountaineers" on October 10, 2014, and the Coordinating Committee for Prediction of Volcanic Eruptions created a study group to review the existing volcano monitoring and warning systems (JMA, 2014b). For the 2014 Ontake eruption, a lack of observatory system, insufficient knowledge about precursory phenomena, and immature tools for information transmission to visitors was pointed out (JMA, 2015). Confusion about warning levels and volcanic activity levels resulted in a misinterpretation of risk. The work of the committee is reflected in "explanatory information about the situation of the volcano" on May 18th. Furthermore, the JMA established an "Eruption Notice" on August 4, 2015 (JMA, 2016). It was carried out prior to information dissemination strengthening for climbers who registered the application software with the communication terminal.

2.2. Relationship with Local Disaster Prevention

Nakamura (2013) and Kuri (2016) reported a shift from structural measures to non-structural measures of disaster prevention. A summary modified from Kuri (2016) about public information of the JMA and information media for residents is shown in Table 1. Until around 2000, these announcements were heavily dependent on the observational sector of the system; later, emphasis was placed on the information transmission sector.

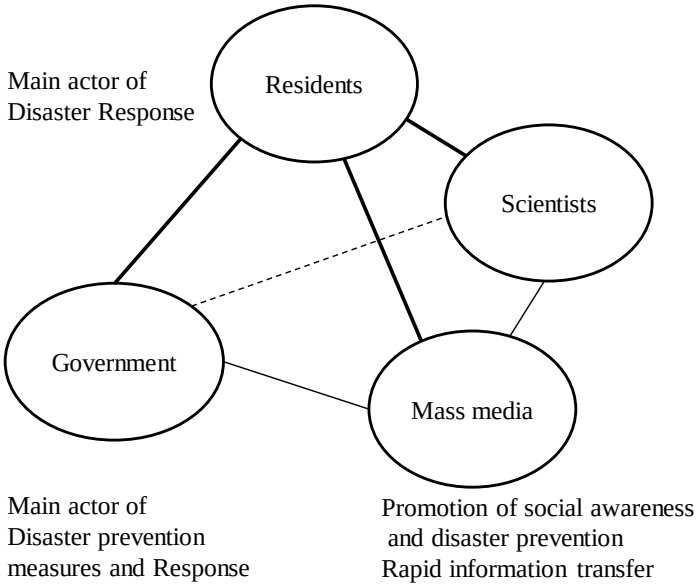

Figure 2 Tetrahedron of disaster prevention (Okada, 1997)

Table 1 Volcano Disaster Prevention System, and Relationship around Residents in Japan Modified from Kuri (2016).

Year	Observation system and volcano disaster prevention system			Relationship around residents
	Stage	Target	Event	
1973 1974	Early stage	Observation around expert	Plan of Volcanic Eruption Prediction Volcanic Eruption Prediction Coordinating Committee	
1994	Improvement stage of the observation instrument and observation system		Interference SAR GPS observation in the South Kanto and Tokai area	
1996			GPS observation point high-density arrangement, GPS continuous observation system operation (GNSS)	
2000	Transition stage	Information delivery to local governments		Usu: Face-visible relationship Miyakejima: Internet communication between residents and volcanologists.
2003 2004			Volcanic activity level by the JMA Interference SAR "High-precision ground deformation survey"	
2007	Improvement stage of the information delivery system	Information delivery to residents	Eruption warning level by the JMA	
2008			Basic practical plan of the volcanic disaster prevention countermeasure meeting for volcano information	
2011 2012 2013			Volcanic Disaster Prevention Council Law concerning strengthening of the fire brigade with the local disaster prevention force as its core by the Fire and Disaster Management Agency	Kirishima: Hot line between Takaharu Town and volcanologists.
2014 2015		Information delivery to residents and visitors	Emergency warning by the JMA Information for volcano tourists by the JMA Enforcement of the Act on Special Measures for Active Volcanoes by the Cabinet office Quick announcement of eruption by the JMA	Kuchinoerabujima: The fire brigades as corresponding actors in planning and action

Okada et al. (1997) show the relationship between residents (disaster response of actors), government (actors of disaster measures), mass media (information on intermediary support), and scientists (provision of expertise), called the "tetrahedron model of disaster mitigation" (Figure 2). It had a high affinity with the system in 2004, in which local government decided the action for disaster

mitigation based on the findings of experts. However, in the 2000 Usu eruption the pre-built relationship between experts and residents lead to smooth evacuation operation and, later, the construction of face-to-face relationships was recommended (Okada, 2008; Hayakawa, 2003). In addition, the development of Internet technology since around 2000 allowed immediate and direct exchange of information between expert and residents. This was utilized in the 2000 Miyakejima eruption because there were also the geographical conditions of an isolated island (Hayakawa, 2004).

Recently residents have come to act in local systems of disaster prevention through the Local Volcano Disaster Prevention Council more than in a past. However, in the 2011 Shinmoedake eruption in Kirishima, it was also the case that local administration was puzzled about making judgment, because of the judgment gap between a group mainly comprising the JMA and a group mainly composed of scientists of the local university (Kuri, 2016).

The Central Disaster Prevention Council made an evacuation plan on December 27, 2011 and on September 6, 2012, on the basis of the Volcanic Disaster Countermeasures edition of the revised Basic Disaster Management Plan as well as on the Local Volcano Disaster Prevention Councils managed by each prefecture, including prefectures, municipalities, local meteorological observatories, local administrations, erosion control departments, and volcano experts. It became a system to promote the setting and improvement of disaster risk reduction. It means that the relationship was slightly modified after establishment of the eruption warning level. That is, each Local Volcano Disaster Prevention Council became to be based on the premise that to carry out a pre-determined. Residents played a role not only in action during emergency, but also in pre-decision-making, for example, evacuation planning. Furthermore, the "Act concerning strengthening of the fire brigade with the local disaster prevention force as its core," based on lessons from the Great East Japan Earthquake, was enforced on December 13, 2013 (Fire and Disaster Management Agency, 2013).

In 2014 an eruption of Mt. Ontake occurred. Sakamoto (2015) pointed out that residents are unfamiliar with evacuation policy, which makes it difficult for them to evacuate when eruptions occur. For better disaster management, Okada (2015) emphasized the importance of keeping an equal level of each sector in order to shape the tetrahedron.

2.3. Tourism and Volcanic Information

Hiroi et al. (1992) and Koyama (2005) reported that local governments appeared to resist reporting volcanic activity, as these announcements, combined with communications about evacuation planning by local government, tend to create fear and to give the impression that the region is unsuitable as a tourist destination. Kuri et al. (2016) pointed out that this situation is changing, in part due to activities of the Japanese Geoparks Network (JGN) established in 2007. Coexistence of tourism and disaster prevention has become more important to save residents and visitors and to keep their livelihoods. There are also movements such as strengthening cooperation with tourism through the volcano disaster prevention councils and tourism.

3. Interview Survey on Disaster Prevention and Awareness related to the 2015 Mt. Shindake Eruption on Kuchinoerabujima

Interview surveys were carried out in July and October, 2015 and March, 2016. The main interviewees were staff of the Miyanoura and Kuchinoerabujima branches of the YTG (Yakushima Town Government) offices, members of the Kuchinoerabujima fire brigade, and district leaders. The focus of this section is the background to rapid evacuation of the region.

This study analyzes volcanoes solely on the basis of scientific information related to evacuation actions, and information gleaned from interviews but without personal details, conforming to the ethical regulations of the author’s organization. Original expressions are retained to the extent possible.

As a reference for the interview, Table 2 shows the recent activity history of Kuchinoerabujima volcano from the Japanese active volcano summary (JMA, 2013, 4th edition), to which information after 2014 has been added.

Table 2 Recent Activities of Kuchinoerabujima Volcano.

Year	Event	Area	Activity and Damage	Memo from interview and others
1841	Eruption on May 23 Explosive eruption on August 1	Shindake Shindake	Details unknown. Volcanic lapilli reached on Maeda district. 1 victim.	
1906	Eruption?	-	Details unknown.	
1907	Eruption?	-	Details unknown.	
1914	Sound	-	Sulfur flow.	
1931 (S6)	Explosive eruption on April 2 Volcanic explosion on May 15	West part of Shindake	Volcanic sounds started from March. Land slid. 2 victims. Damage for horses, rice, and vegetables. Ash fall, Sulfur flow, land uplift.	As there were no eruptions experienced on the island, 1097 people conducted large-scale evacuation outside the island.
1932	Sound	-	Columnar activity and sound started from July 23.	
1933-34	Some eruptions from December 24, 1993 to January 11, 1994.	Shindake	Complete burning of Nanakama district. 8 victims. 26 injures. 15 houses completely burned. Severe damage to livestock and fields.	
1945	Eruption on November 3	East crater wall of Shindake	Fracture eruption, bomb, ash fall.	
1966 (S41)	Eruption on November 22	Shindake	3 injured. 1 cow. Aerodynamics reached Kagoshima City and Tanegashima Island. Small pyroclastic flow.	No large-scale evacuation outside the island.
1968-69	Eruption	Shindake	Some eruptions from December 1968 to March 1969.	
1972	Eruption on September 2	Shindake		
1973	Eruption	Shindake	November 5 to 9.	
1974	Eruption on July 3	Shindake		
1976 (S51)	Eruption on April 2	Shindake	Explosive sound. Ash fall in the northwesterly direction at a 2km distance.	Memory of evacuation drill at elementary school.
1978	-	-	-	The first Local Disaster Management Plan by the YTG
1980	Small phreatic explosion on September 28	East slope of Shindake.	Many explosion crater for the length of 800 m in the north-south direction (same area as 1933). Volume of discharge magma was 0.0001 DREkm^3 (VEI=1).	
1982	Fumarolic activity	Shindake	4 fumarolic gas craters opened in October.	
1996	Earthquake	-	Numerous volcanic earthquakes from January to June.	
1999-2000	Earthquake	-	Numerous volcanic earthquakes from July 1999 to February 2000. Earthquakes in the northeast sea area increased.	Some residents climbed up the crater, although with recognition of activity around 2001.
2003	Earthquake, Volcanic tremor	-	Numerous volcanic earthquakes from January to February. After February some volcanic tremors.	
2004	Earthquake, Volcanic tremor in February	-	Numerous volcanic earthquakes. Volcanic tremors continued.	
2005	Earthquake, Volcanic tremor, Ground deformation, Fumarolic activity	-	Numerous volcanic tremors. From February to April, a little more fumarolic activity. Land expansion around Shindake Crater from January to May.	Start of the Kuchinoerabujima National Park Project

Table 2 Recent activity list of Kuchinoerabujima volcano (continued).

Year	Event	Area	Activity and Damage	Memo from interview and others.
2006	Earthquake, Volcanic tremor, Ground deformation	-	Numerous volcanic earthquakes and tremors. Land expansion around Shindake Crater from September to December.	
2007	Earthquake, Volcanic tremor	-	Numerous volcanic earthquakes and tremors. These activities oscillated.	Establishment of the "warning level" by the JMA. Warning level: Dec. 1, 2007 (2), Jan. 25, 2008 (1) .
2008	Earthquake, Volcanic tremor, Ground deformation	Shindake	Numerous big volcanic earthquakes on September 4. Land expansion around Shindake Crater and numerous volcanic tremors from September 2008 to February 2009. White columnar activity started in October at the south wall of Shindake.	Warning level: Sep. 4, 2008 (2), Oct. 27, 2008 (3) .
2009	Earthquake, Volcanic tremor	-	Numerous volcanic tremors in April. Active volcanic earthquake in September.	The first entry of the Nankai Hyoutan-jima Mountain and Sea Study Program. Warning level: Mar. 18, 2009 (2), Aug. 4, 2009 (1), Sep. 27, 2009 (2), Oct. 30, 2009 (1).
2010	Earthquake, Volcanic tremor, Ground deformation	Shindake	Numerous volcanic earthquakes from January to April. Numerous volcanic tremors from March to December. Land expansion around Shindake Crater started from September.	
2011	Earthquake	-	Numerous volcanic earthquakes in December.	The revised Local Disaster Management Plan by YTG. Warning level: Dec. 15, 2011 (2), Jan. 20, 2012 (1).
2014	Eruption	Shindake	On August 3	Warning level: Aug. 3, 2014 (3), Aug. 7, 2014 (3). Kuchinoerabujima evacuation drill on November 14, 2014.
2015	Eruption	Shindake	On March 29 and July 19.	Warning level: May. 20, 2015 (5), Oct. 21, 2014 (5), Jun. 14, 2016 (3). Full evacuation from the island.

3.1. Perception of Past Eruption Activities

The eruption in 1931 brought an exaggerated response: 1097 residents left the island. This was because no one had ever experienced an eruption on the island at that time. Maeda and Honmura districts, which are old settlements, suffered little damage. The main victims were sulfur-mining companies and their facilities from outside the island.

The eruption in 1966 was greater than that in 1931, but fewer people evacuated. Residents prepared for the next eruption because they had experienced small eruptions every several years since 1966. Some people in their 40s remembered the evacuation drills at elementary and middle school in the 1970s. The people recognized that eruptions could happen about every 20 to 30 years. Many residents participated in the evacuation drills, which included escaping in the backs of dump trucks. An island-wide evacuation system was established, replacing community-level systems. They could not provide any details on the years after the 1980s because they had left the island for about a decade.

3.2. Issues That Became Apparent before the 2014 Eruption

Residents in Kuchinoerabujima had high disaster awareness preceding the August 3, 2014 eruption, although a downward trend was reported in the rate of resident participation in evacuation drills, which had been carried out continuously in recent years. Simultaneously the Local Disaster Management Plan, which was prepared in 2011, was being revised by YTG at the time of the 2014 eruption.

There were numerous earthquakes, as many as 100 to 200 per day, in 2001, but residents did not have a sense of imminent danger. In fact, some residents had climbed to the crater in 2001, when the eruption was in a temporary quiescent period. At the same time, members of the fire brigade worked managing guest houses, leading guided tours, the maintaining the infrastructure, including a recently created volcano observatory, for their livelihood. These activities and communication experiences provided new information on the volcano. An expert from the university explained to them about the possibility of a large-magnitude eruption that could result in evacuation from the island. Members of the fire brigade recognized the possibility of an eruption before it occurred in August 2014. And they expected that it would be possible to predict eruptions in sufficient detail for step-by-step evacuation, from evacuation preparation to the actual order. They reviewed the evacuation plan based on the eruption scenario they considered would arise. In the 2014 evacuation action policy, residents were instructed to board evacuation vessels at the community level, even though defects in the evacuation system, such as the unclear safety of the port and evacuation routes, had been recognized. The system was not improved due to a lack of funds, despite the fact that an application to the administrative office had been made.

As the following subsection shows, these worries were realized in the 2014 eruption, and these experiences led to a renewal of the evacuation plan and the evacuation drill.

3.3. Issues That Became Apparent during the 2014 and the 2015 Evacuation

In this subsection, we will report (1) results of the July 2015 interviews about disaster prevention awareness related to the August 2014 volcanic activity, disaster prevention awareness since the August 2014 volcanic activity, and the May 2015 evacuation decision; and (2) results of the October 2015 interviews and re-interviews about the 2015 evacuation report, including the issue of support for future evacuations. Sakamoto et al. (2016) reported these evacuation operations of the 2014 and 2015 eruption, which are summarized in this subsection and in Table 3. The volcanic activity information leading to the evacuation of residents from Kuchinoerabujima following the May 29 eruption is reported in Kuri (2016).

As mentioned above, the fire brigade recognized the possibility of an eruption before it occurred in August 2014. However, the 2014 eruption without any remarkable signs surprised them. At the emergency onsite discretion, with the memory of evacuating to Banyagamine during the previous 1980 eruption, the emergency evacuation site was changed from Honmura district to Hayagamine, and the residents were guided. Some residents did not want to evacuate, but members of the fire brigade tried hard to persuade them, which is why it took almost two hours to complete the evacuation to Banyagamine. This emergency evacuation was operated by the fire brigade without the YTG. These experiences in August 2014 and awareness of the installation of and inspection by observation instruments created a heightened perception of disaster risk reduction. They revised the evacuation plan. The document was titled “Review Report on the Explosive Eruption at Shindake of 12:24, August 3, 2014” and handed to the YTG.

Disaster drills based on the Kagoshima Prefecture Tsunami Evacuation Plan were started in September 2014. In Kuchinoerabujima an evacuation drill was held on November 14, 2014. At the drill, an alert siren with the message that the volcano was suddenly erupting was transmitted.

Table 3 Outline of Disaster Prevention Operations in the 2014 and 2015 Eruption Modified from Sakamoto et al. (2016).

Volcanic event	Public action	Fire brigade action
August 3, 2014 12:50: Eruption	13:00 YTG: Establishment of Yakushima Town Disaster Countermeasures Headquarters. 14:00 YTG: Received calls about the safety of Kuchinoerabujima residents.	[Main interviewee: Chief of the fire brigade] Just after the eruption: Patrolled settlements in the fire truck telling residents to evacuate. Just after pyroclastic flows: Visual confirmation. Decided to change evacuation site from Honmura to Banyagamine.
May 23, 2015 08:00: Felt earthquake (Magnitude: 2.3)	10:45 JMA: Explanatory Information on Volcano Activity No.42 16:00 Prefecture: Disaster Information Coordination Meeting for Kuchinoerabujima Volcano Eruptions.	[Main interviewee: Sub-chief of the fire brigade] Kept wearing their uniforms every time. Checked the list of residents and the evacuation process. 13:00 Study meeting for residents by the JMA 19:24 Contact with (calling to) the YTG
May 29, 2015 09:59: Eruption	10:07 JMA: Volcanic warning level of 5. 10:07 Kagoshima Prefecture Government (KPG): Establishment of Kagoshima Prefecture Disaster Countermeasures Headquarters. 10:07 YTG: Establishment of Yakushima Town Disaster Countermeasures Headquarters. 10:15 YTG: Evacuation recommendation. 10:20 YTG: Evacuation order. 10:30 KPG: Disaster prevention helicopter departed from Kagoshima City to Yakushima to pick up the mayor of the YTG, and then to Kuchinoerabujima. 10:40 KPG: Request to the SDF for disaster relief 12:15 Coast Guard: Helicopter landed at Banyagamine. 12:30 KPG: Disaster prevention helicopter arrived at Banyagamine with the mayor of the YTG. 12:52 Coast guard: Patrol ship arrived at Yumugi district. 14:38 YTG: The vessel Taiyo arrived at Honmura Port on Kuchinoerabujima. 15:45 YTG: The vessel Taiyo departed from Honmura Port. 15:50 Helicopter rescue in Yumugi district. 16:30 Central government: Establishment of a government local liaison coordination room. 17:30 YTG: The vessel Taiyo arrived at Miyanoura Port on Yakushima.	Just after the eruption: Visual confirmation in the field in Maeda district. Evacuated from Maeda to Honmura district with families and neighbors by private car. Started emergency evacuation operations from Honmura district to Banyagamine. Placement of members to lead emergency evacuation to Banyagamine. Back to Maeda district to rescue residents by a fire brigade car. 10:23 Almost all residents assembled at Banyagamine. (Almost finished emergency evacuation.) 10:30 Confirmed one missing man in Mukaehama district 10:36 Drove to Mukaehama district by a fire brigade car. (No land access due to pyroclastic flow.) 10:41 Ordered fisherman's boat to undertake rescue. 11:02 Found the missing man in Mukaehama district. 11:03 Called the YTG about the missing man. 11:19 Rescued the missing man. 11:25(12:25?) Arrived at Banyagamine after arrival of the mayor of Yakushima Town. 14:35 Assembled at Honmura Port. 15:45 Departed from Honmura Port by the vessel Taiyo.

On May 23, 2015, the number of volcanic earthquakes had increased in Kuchinoerabujima, and a felt earthquake occurred at 08:00. The JMA issued a warning that there may be a possibility of large rock falls caused by eruption into the area within a 2-km radius from Shindake Crater. Residents

requested the JMA to hold a study meeting to explain the updated situation of the volcano activity. The JMA told residents about the possibility of an eruption, the definition of volcanic earthquake and tremor, an example case of signs of eruption, difficulty of prediction, evacuation before official warnings, and so on. The fire brigade prepared for a possible sudden eruption, wearing their uniforms every time and checking the evacuation process of residents, including people who need special assistance for evacuation.

On 09:59 May 29, 2015, the explosive eruption occurred. However, they were surprised at the sudden eruption and the rapid escalation of the warning level, directly from 3 to 5, on May 29, 2015. Almost all of the residents evacuated to Banyagamine within 30 minutes. Members of the fire brigade felt that the drill on the island was sufficiently effective. The YTG based its own evacuation drills on a division of roles. They recognized that it was reasonable for residents to take part in soft measures such as evacuation drills, whereas the town implemented the hard measures, including familiarizing the country and the province with the subsidy program.

3.4. Issues That Became Apparent upon Residents' Return to the Island

In this section we will report the results of (1) the October 2015 interviews about the May 2015 evacuation (including the issue of future evacuation operations) and resident opinions about returning to the island; and (2) the March 2016 interviews about the residents' decision to return, the circumstances after their return, and their thoughts about the volcano after their return. In addition, the situation of biosphere reserves, so-called eco-parks in Japan, is reported. Events before the residents' return were as follows:

September 25, 2015: Installation of Kuchinoerabujima Reconstruction Headquarters.
October 16, 2015: Meeting of evacuees from Kuchinoerabujima by the YTG
October 21, 2015: Eruption warning maintained at Level 5 by the JMA
October 22, 2015: Announcement by the YTG that a local measures team would be established the following month
October 27, 2015: Temporary return of 58 residents; conducting by the YTG of a questionnaire survey of returning residents
November 16, 2015: Deployment of the Kuchinoerabujima Reconstruction Local Emergency Response Team
November 20, 2015: Partial restoration of power on Kuchinoerabujima
December 24, 2015: Restoration of GNSS (Global Navigation Satellite System) continuous observation (Kuchinoerabujima electronic reference point)
December 25, 2015: Issuance by Yakushima Town mayor of a statement releasing evacuation instructions and announcing a free municipal ferry service for returning residents
January 8, 2016: Resumption of schools
January 16, 2016: End of municipal ferry service for returning residents
Before eruption: 86 households, 137 people
After eruption: 23 households, 34 people (as of January 16, 2016)

The YTG held an explanatory meeting for evacuees from Kuchinoerabujima on October 16, 2015. More than 60 people, including residents, administrative officials, and journalists, attended. On October 21, the mayor explained the policy for preparing to return to the island in the same year, referring to the opinions of the Coordinating Committee for Eruption Prediction. The chief of the General Affairs Department discussed considerations related to the establishment of a committee aimed to prepare residents to return to the island and establish basic services such as water, electricity, and communications, and other public support. This discussion of procedures being put in place confirmed to residents the intention to return them to the island. These procedures were based on fiscal year plans over several years, and a 10-year reconstruction goal was proposed. The chief of the General Affairs Department said that establishment of an organization to arrange residents' return was under consideration. A reconstruction organization separate from that in the management headquarters was proposed for the volcanic disaster. Processes for confirming plans related to basic services and official support measures were explained. The question-and-answer session showed that residents were interested in official government financial support. The local government based its decision about the

return on the opinion of the JMA that the volcanic activity was decreasing, while residents were more aligned with the assumption that volcanic activity would continue.

Financial support for households was considered. The volcanic explosion was just one source of damage. Houses were also damaged by typhoons, wind, and rain. Schools were damaged by mud flow. Reaching a consensus about how to respond to grant applications has been a relatively smooth process, as there was little discretion in determining the priority of applications. Decisions about restoration work and the difficulty of maintaining safety measures all depended on changes in the volcanic activity. The residents' return went smoothly under the assumption that it would proceed as planned. The restoration of basic services, such as electricity, water, gas, and communications, has been relatively smooth. With this support, residents regained a strong sense of autonomy and an awareness of the risk of further eruptions.

Temporary housing plans affected the residents' decision to return. After two months, the media broadcasted long-term evacuation plans for the island. Residents hoped that these plans would include support both for people who wanted to return and for those who wanted to continue the evacuation. In their view, the temporary housing plan provided support for only those residents who wished to remain in evacuation; this was seen as an impediment to plans to return. Ultimately, the local government decided to keep its temporary housing preparations for the next eruption.

3.5. Tryout for Volcanic Disaster Prevention after Return to the Island

The interview survey was conducted in March and November 2016. In March, the 10-year plan, including details and background, that the residents proposed to the town in October 2015 was the focus. In November, "living after returning to the island," "awareness for volcano, " and "tryouts for disaster prevention" were heard.

The reconstruction goals of the 10-year plan were based on the plan to make Kuchinoerabujima a biosphere reserves. Initially, in 2005, the residents submitted a proposal to the local government to create a biosphere reserves over the entire island of Kuchinoerabujima; this proposal was supported by government promotion of the project. In addition, the Nankai Hyoutan-jima Mountain and Sea Study Program was created in 2009, incorporating childcare and environmental education for migration. Tourism is a priority around the volcanic area. The eruption on August 3, 2014 increased awareness of the necessity to plan for tourist safety. The cancellation of the ferry due to weather disrupted the climbing plans of a number of visitors, preventing their deaths in the eruption.

The timeline for establishing a biosphere reserves is as follows:

July 14, 2014: Creation of the Yakushima Kuchinoerabujima UNESCO Biosphere Reserve Promotion Council
August 24, 2015: Recommendation to pursue registration of the Yakushima Kuchinoerabujima Biosphere Reserve with the Japanese National Commission for UNESCO, 33rd MAB subcommittee, hosted by MEXT (Ministry of Education, Culture, Sports, Science and Technology, Japan)
February 26, 2016: Application form submission for a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Biosphere Reserve
March 20, 2016: Acceptance of the Yakushima–Kuchinoerabujima Biosphere Reserve application at "Biosphere Reserves, Man, and the Biosphere," sponsored by MEXT and held at the MAB International Coordinating Council meeting in Peru
June 14, 2016: Full-scale reconstruction; dropping of the eruption warning level from 5 (Evacuate) to 3 (Restricted access)

A Kuchinoerabujima branch officer said, on November 2016, that about 100 to 110 residents were returning. Dormitories of Hiroshima University and Keio University were moved from Maeda to Honmura district after the return.

A woman in the Maeda district said that she returned soon after the lifting of the access restriction of the Maeda district. Eruption situations are not always the same. On August 4, 2014, it seemed as though a rocket had fallen into her backyard; on the other hand, on May 29, 2015, she found herself in the volcanic cloud without any volcanic sounds. On May 29, 2015, her family thought that she might have perished, and they were greatly relieved by her call telling them, "I am in Banyagamine." The first priority in an evacuation drill is to "protect myself by myself." First, one must reach Banyagamine. Next,

food and cooking are considered. These aspects would be discussed among evacuators after the emergency evacuation. After some calm in the 2014 eruption, the respondents answered that the women's association "Sha-sha-bu" (blueberry) delivered rice balls. She did nothing in particular for the return to the island after the evacuation of the whole island in the eruption of 2015, under the perception that governmental judgment about returning was based on the judgment of the Eruption Prediction Liaison Committee.

A fire brigade member in the Maeda district relating the work of regional promotions said that, although he had been participating in evacuation drills, he had not experienced cooking in a shelter. So, in the next drill, he planned to provide miso soup at a shelter on Banyagamine. The fire brigade had not determined evacuation dispatch, because it could not determine where a person was, which also depended on the time zone, even on that day. On the other hand, grasping the number of cars on the island and who on that day knows each other, so they can deal flexibly in case of emergency. It is unhelpful to make plans in vain. Through the experience of August 2014, they reviewed the training that was useless in the past. It was more important to make a list of car owners than to decide on dispatch. Currently there are about 80 car owners on the island and 60 came to Banyagamine in May 2015. It is generally also possible to grasp who is in the evacuation site from the number of cars. Especially on remote islands, this is an essential procedure for the Land Transport Bureau. In the evacuation to Banyagamine, it was revealed that people trying to return home to retrieve forgotten items were the cause of accident, and the reverse car flow was a source of confusion. As another task, there were even many fire brigade members who did not know what to do after arriving at Banyagamine. Currently, the responsibilities are organized, such as the director in charge of Banyagamine as a director and guide in the district. In the evacuation of May 2015, we saw the issue about of evacuation management in Yakushima Island as a remote island. Smooth operation is enabled if priority is given to fatigued people; if evacuation is prolonged, a decision is made to divide by age structure of households.

Unlike the liaison network of the administration-/-district, in an emergency, priority is given to the system of fire brigades. Of course, when necessary in evacuation centers, etc., the communication network of administration-/-district is utilized. The fire bridge thought that, while they are in a team under emergency, after the emergency, they should be in the district units. As a new initiative, the fire brigade conducted a study on the framework of salvage rescue. Although there are few examples of this system, there are, as a matter of fact, many sea accidents and help in cleaning up of spreading oil is also needed.

On June 1, 2016, an agreement to fund the rebuilding and living support from Kuchinoerabujima volcano eruption between the YTG and Yumugi and Honmura districts in Kuchinoerabujima was signed. The YTG currently manages the fund; however, in future, it is important that the islanders themselves decide how to use the reconstruction fund. In a situation of declining population, it is the principle idea that human resource development is important in remote islands, carefully considering promotion of resettlement, human resource development, and child rearing support. They hope to use the fund from the next fiscal year.

In June 2016, a reconstruction committee was established by the offer of direct donation without local government from supporters. The residents were progressing towards independence and considered this fund to be necessary for their independence. Nineteen people, including women, are members. It is a budget for local people to plan and to implement with a vision in the future. Residents give their own suggestions. It seems to be administrative work, but the residents have to be able to do it, and this reconstruction committee also considers it as a place of training. They need experience of management. For example, if a Satoyama Tour were held once, about 80,000 yen would be the income of the district. The accumulation of achievement would suppress opposing opinion. It is necessary to inform them over time and someone have to show it. Whether to do or not is a simple personal choice, but after deciding, it becomes structure selection how to do, which requires training. In any case, they would like to integrate the handling of the above funds here.

The Mountain and Sea Study Abroad Program, with the participation of more than 100 people in 20 years and some of them staying longer than the regular period, was restarted after the return. Family study abroad is recommended, and jobs for parents, such as public facility management and school clerking, are proposed; however, in many cases, children were selected to study abroad, because of the circumstances of brothers and sisters and the strong hope of the child him/himself. These activities assist children who will nurture society. This society designed an original T-shirt of Kuchinoerabu,

Kuchinoerabu Big Bat and Yaku Deer. One family undertook coverage of the observation of Kuchinoerabu Big Bat through a mass media channel.

A leader of the Guardians Association said that they had decided to make a disaster manual as an activity of the Guardians Association soon after returning to the island in January 2016. In October 2016, they published a manual for natural disaster on Kuchinoerabujima, including an original hazard map and messages from children, supported by the Yakushima Environmental and Cultural Foundation (public good). She hoped that the children in the Kuchinoerabujima would keep memories of the eruption, and held a workshop of walking around hazard risk places with children in March and June 2015. She also hoped to let the children, residents, and visitors know about hazard risk places in plain language. For visitors, she planned a joint event of remote islands held in late November in Tokyo, to introduce the activity of making a natural disaster manual as well.

4. Discussion

4.1. Relationship between Experts and Residents

The JMA gave a presentation on monitoring and information of volcanic activity based on the Meteorological Service Act. In fact, the residents recognized that the JMA had the role of providing information, as the residents requested that the JMA comment on information on the situation of the volcano just after the felt earthquake on May 23, 2015. However, there were no remarks concerning residents' awareness of the category of information from the JMA.

Although information about volcanic and earthquake activity has been available since around 2001, residents continued to climb to the volcanic crater. This suggests that sufficient transmission of information about volcanic activity does not necessarily lead to proper disaster prevention action. After that, the relationship between residents and experts also became closer than before. Some of the fire brigade had acquired academic information from the university through the maintenance job at the observatory. And they use this information for planning evacuation from the volcano. The results suggest that it is important not only to build relationships with highly interested local residents as non-experts, residents who can communicate information, including uncertainties, but also to communicate information among experts, government bodies, and designated members of the news media.

On the other hand, knowledge of magma monitoring created the perception that experts could predict eruption. Therefore, residents were disappointed that the 2014 and 2015 eruptions were not predicted, and the trust in experts was shaken. During our interview survey some interviewees expressed a hope for more information as follows. "Highly accurate observations might make prediction of the movement of magma possible. Such observation systems gather signals of magma uplift. The first such cases occurred at Iwate in 1998 and in Sakurajima in August 2015. However, an uplift signal is not necessarily an eruption signal. Even if these systems can report the volume of the magma supply from deep underground, it is difficult to estimate the timing and the magnitude of an eruption from magma uplift." Describing the limits of findings by experts might build a better relationship between residents and experts.

4.2. Relationship between Government and Residents

Government takes the role of decision-making to protect people's lives and bodies from disaster caused by volcanic phenomena defined in the Act on Special Measures for Active Volcanoes. After the establishment of the Local Volcano Disaster Prevention Council, residents came to play a role in the local system of disaster prevention.

Residents in Kuchinoerabujima have a strong spirit of independence. Particularly in an emergency, they must do what they can for themselves in a remote island environment. Not only members of the fire brigade, but also residents have the concept of "self aid (during an emergency evacuation)," "mutual aid (after an emergency evacuation)," and "public aid (as a safety net)." Another resident expected the that government to be familiar with choosing appropriate support measures and document preparation at the reconstruction stage. In the process of thinking about concrete plans for migration and human resource development, the residents themselves came to have the idea of managing funds and the awareness of employing these funds as grants. As a result, the roles of the residents became diversified. The residents are in positive contact with the YTG.

4.3. Relationship between the Media and Residents

Although Hiroi et al. (1992) and Koyama (2005) reported the hesitation of residents to open disaster information, the YTG and Kuchinoerabujima residents have less anxiety about outside harmful rumors. They worry about information leakage of undetermined administrative issues by the media leading to misunderstanding and discrepancy; however, they have less concern about harmful rumors affecting outside tourists by volcanic disaster information. And the residents on Kuchinoerabujima hope that the media will deliver nature stories in Kuchinoerabujima rather than sentimental stories about reconstruction. The reasons that they are not concerned about damage caused by rumors, with a view to tourism, will be discussed in the next chapter. Comparison with other volcanic tourism areas about handling of information openness is a future issue.

4.4. Cooperation between Disaster Prevention Education and Tourism

The purpose of visitors from neighborhoods around Yakushima is mainly fishing, and the purpose of visitors from remote areas is mainly environmental educational excursion in Kuchinoerabujima. The residents selected the biosphere reserves method based on their experience. Kuchinoerabu Big Bat and Yaku Deer are symbols of their activities. In addition, they have a migration policy. Visitors are viewed as latent future migrant candidates. There is a possibility that there may be the understanding that protecting the safety of tourists is beneficial for residents.

Active members of the fire brigade acquired knowledge through activities such as evacuation drills at elementary school and, through their later job with volcanic experts, they improved their knowledge of concrete measures against volcanic eruption dramatically through the experience of the 2014 eruption. Inevitably, they tried to feed back the improved knowledge to the tourism and the migration policy. Their selected works tied with themselves job for livelihood.

In Kuchinoerabujima, independent and subjective activities by residents with some grants made possible a more equal tetrahedral relationship of disaster prevention, which was originated by Okada (1997) as shown in Figure 2. However, this might be the case on an isolated island. Although it is difficult to generalize the handling of volcano tourism and volcanic information in this respect, a model in which residents themselves make decisions independently of safety management and local revitalization can also be applied to other volcanic tourist spots. Comparison with residents' awareness of volcanoes in other areas is a future issue.

5. Conclusion

The immediate evacuation of Kuchinoerabujima causing the 2015 eruption was the result of the relationships built not only among experts, local government, residents, and the media but also among experts and highly interested non-expert residents. It is also suggested that a cooperative system that features disasters and benefits would help the Volcanic Disaster Prevention Council.

After returning, around the proven activity of the Mountain and Sea Study Abroad Program that had been active before the evacuation, they worked on the growth of human resources, disaster prevention education, regional safety, and regional activities including tourism. All of these activities concerned disaster prevention. Additionally, they worked on securing the safety of tourists who may potentially have to migrate. Also, this attitude led to the construction of a resident system.

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