Appendix B – Region 8

Country and regional profiles of volcanic hazard and risk:

Japan, Taiwan and Marianas

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This download comprises the profiles for Region 8: Japan, Taiwan and Marianas only. For the full report and all regions see Appendix B Full Download. Page numbers reflect position in the full report. The following countries are profiled here:

Brown, S.K., Sparks, R.S.J., Mee, K., Vye-Brown, C., Ilyinskaya, E., Jenkins, S.F., and Loughlin, S.C. (2015) Country and regional profiles of volcanic hazard and risk. In: S.C. Loughlin, R.S.J. Sparks, S.K. Brown, S.F. Jenkins & C. Vye-Brown (eds) *Global Volcanic Hazards and Risk,* Cambridge: Cambridge University Press.

Region 8: Japan, Taiwan, Marianas

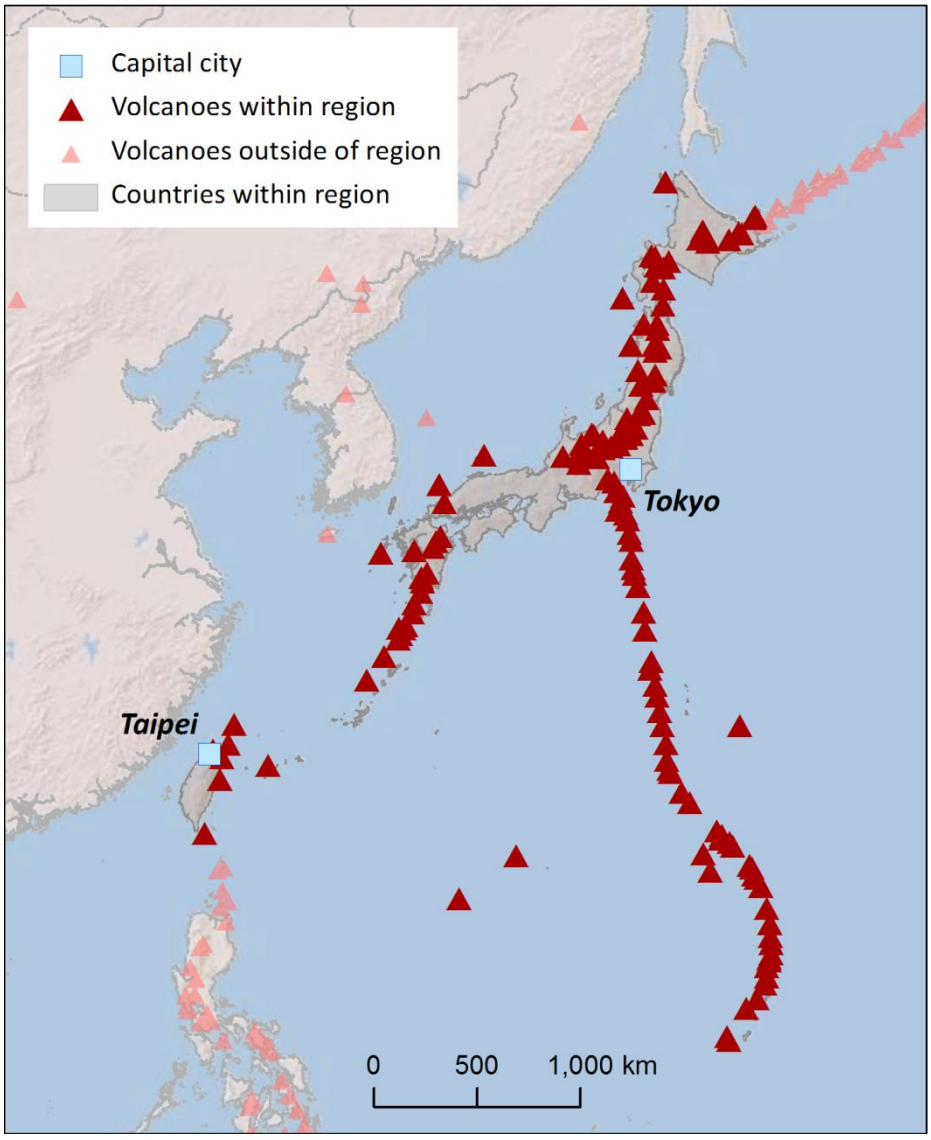

Figure 8.1 The distribution of Holocene volcanoes through the Melanesia and Australia region. The capital cities of the constituent countries are shown.

Description

Region 8: Japan, Taiwan and the Marianas comprises volcanoes through the main Japanese arc, the Izu Islands, Marianas Islands and the Ryuku Islands. Taiwan is considered here, separately to China. Three countries are represented here. All are included in this regional discussion and individual country profiles are provided.

Country	Number of volcanoes
Japan	114
Taiwan	8
USA – Marianas	21

Table 8.1 The countries represented in this region and the number of volcanoes. Volcanoes located on the borders between countries are included in the profiles of all countries involved. Note that countries may be represented in more than one region, as overseas territories may be widespread.

143 volcanoes are located in Japan, Taiwan and the Marianas. Most of these volcanoes are in Japan. Although at the junction of a number of plates, volcanism in this region can broadly be described as related to the subduction of the Pacific Plate beneath the Eurasian Plate.

A large number (26) of submarine volcanoes are located in this region, along the Izu-Marianas arc. Subaerial volcanoes vary in form throughout the region, though most (64) are stratovolcanoes and complex volcanoes. The rock type through this region is dominantly andesitic, though ranges from basaltic to rhyolitic.

A range of activity styles and magnitudes are recorded through the Holocene, with eruptions of VEI 0 to 7. About 75% of eruptions here have been small, at VEI 0 to 2, however 117 eruptions (over 10%) have been large explosive VEI ≥4 events. These VEI ≥4 eruptions have largely been restricted to Japan, with just three in the Marianas Islands. The largest Holocene eruption in this region was the VEI 7 eruption of the Akahoya tephra from Kikai, in about 4350 BC. This eruption produced pyroclastic flows that travelled 100 km across the sea and produced widespread ash fall, devastating southern and central Kyushu.

Seventy-seven volcanoes have historical records of 874 eruptions, 97% of which were dated through direct observations. The large number of geological age (pre-1500 AD) eruptions reflects a relatively detailed Holocene record achieved through significant tephrochronological studies. 6% of historical events have produced pyroclastic flows and 8% have resulted in lahars. A further 8% have produced lava flows.

About 9% of historical eruptions (77) have resulted in loss of life. Most volcanoes have a small proximal population, largely reflecting the number of submarine volcanoes. About a quarter of volcanoes have a high local population. The risk levels reflect the varying population size and assigned hazard scores. Eleven volcanoes here are classed at Risk Level III (24% of classified volcanoes), reflecting large population sizes and frequent and/or large explosive eruptions. All Risk Level III volcanoes are in Japan.

Monitoring and research groups are active in Japan, Taiwan and the Marianas Islands, with monitoring focussed on the volcanoes of higher risk.

Volcano Facts

Number of Holocene volcanoes	143
Number of Pleistocene volcanoes with M≥4 eruptions	91
Number of volcanoes generating pyroclastic flows	52 (160 eruptions)

Number of volcanoes generating lahars	39 (98 eruptions)
Number of volcanoes generating lava flows	47 (188 eruptions)
Number of eruptions with fatalities	85
Number of fatalities attributed to eruptions	22,770
Largest recorded Pleistocene eruption	The largest recorded Quaternary explosive eruption occurred at 87 ka with the eruption of Unit 4 from Aso in Japan.
Largest recorded Holocene eruption	The M8.1 Akahoya tephra eruption of Kikai in 7330 BP is the largest recorded Holocene eruption in LaMEVE in this region. Even at M7.2 which the volume indicates, this would still be the largest eruption in the region.
Number of Holocene eruptions	1,481 confirmed Holocene eruptions.
Recorded Holocene VEI range	0 – 7 and unknown
Number of historically active volcanoes	77
Number of historical eruptions	874

Number of volcanoes	Primary volcano type	Dominant rock type
12	Caldera(s)	Andesitic (8), Dacitic (2), Rhyolitic (2)
64	Large cone(s)	Andesitic (48), Basaltic (15), Dacitic (1)
8	Lava dome(s)	Andesitic (5), Dacitic (1), Rhyolitic (2)
8	Shield(s)	Andesitic (5), Basaltic (2), Dacitic (1)
4	Small cone(s)	Andesitic (1), Basaltic (2)
26	Submarine	Andesitic (8), Basaltic (5), Dacitic (3), Rhyolitic (2), Unknown (8)

Table 8.2 The volcano types and dominant rock types of the volcanoes of this region according to VOTW4.0.

Eruption Frequency

VEI	Recurrence Interval (Years)
Small (< VEI 4)	1
Large (> VEI 3)	40

Table 8.3 Average recurrence interval (years between eruptions) for small and large eruptions in Japan, Taiwan and the Marianas.

The eruption record indicates that on average small to moderate sized eruptions of VEI <4 occur in this region with an average recurrence interval (ARI) of about a year, whilst the ARI for large eruptions is longer, at about 40 years.

Eruption Size

Eruptions are recorded through the Japan, Taiwan and Marianas region of VEI 0 to 7, representing a range of eruption styles from gentle effusive events to very large explosive eruptions. VEI 2 events dominate the record, with about 50% of all Holocene eruptions classed as such. Just over 10% of eruptions here are explosive at VEI ≥4.

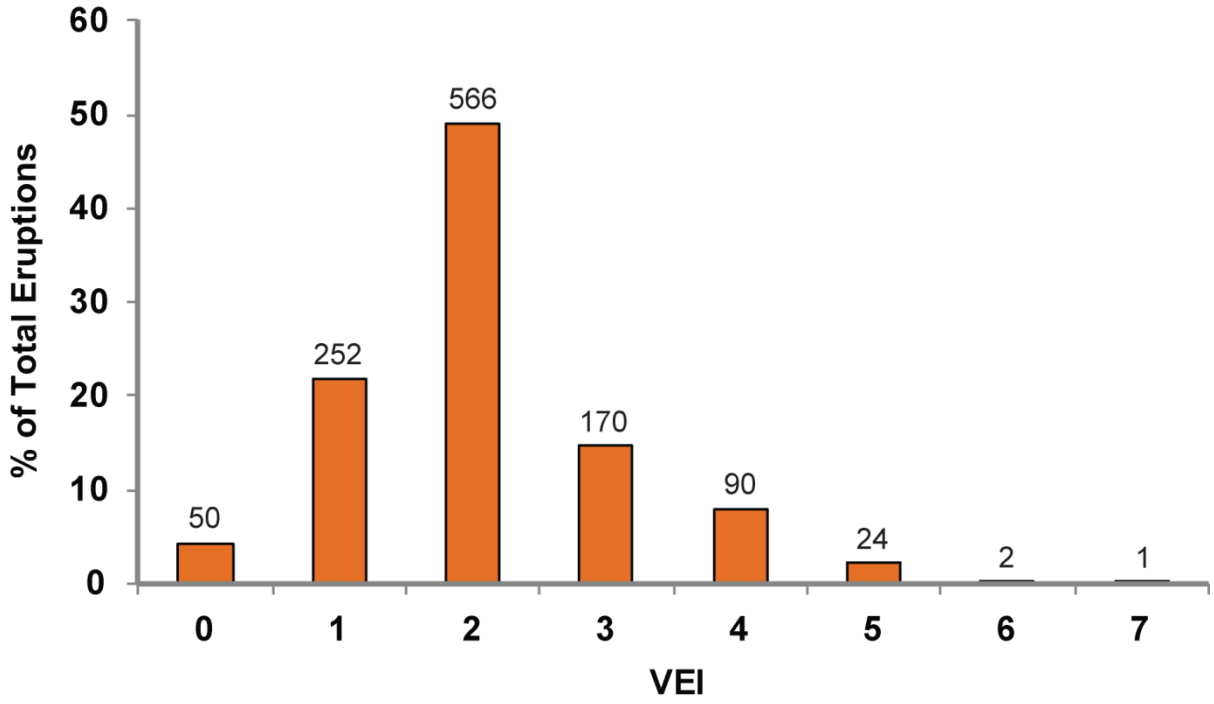

Figure 8.2 Percentage of eruptions in this region recorded at each VEI level; the number of eruptions is also shown. The percentage is of total eruptions with recorded VEI. A further 326 eruptions were recorded with unknown VEI.

Socio-Economic Facts

Total population (2011)	150,587,372
Gross Domestic Product (GDP) per capita (2005 PPP $)	30,660 (Japan)
Gross National Income (GNI) per capita (2005 PPP $)	32,545 (Japan)
Human Development Index (HDI) (2012)	0.912 (Very High, Japan)

Population Exposure

Number (percentage) of people living within 10 km of a Holocene volcano	1,234,976 (0.82 %)
Number (percentage) of people living within 30 km of a Holocene	17,144,484 (11.39 %)

volcano	
Number (percentage) of people living within 100 km of a Holocene volcano	72,295,057 (48.01 %)

Infrastructure Exposure

Number of airports within 100 km of a volcano	35
Number of ports within 100 km of a volcano	107
Total length of roads within 100 km of a volcano (km)	44,523
Total length of railroads within 100 km of a volcano (km)	7,645

CLASSIFIED	**Hazard III**	Pagan; Anatahan	Aogashima	Tokachidake; Rausudake	Hakusan; Niigata-Yakeyama; Towada; Hachijojima; Mashu	Fujisan; Hokkaido-Komagatake; Toya (Usu)	Aira; Unzendake; Shikotsu	
	Hazard II		Suwanosejima; Kuchinoerabujima; Kikai		Kirishimayama; Yakedake; Kurikomayama; Chokaisan; Akita-Komagatake; Akita-Yakeyama; Iwakisan	Ibusuki Volcanic Field; Asamayama; Kusatsu-Shiranesan; Bandaisan; Zaozan		
	Hazard I	Farallon de Pajaros	Io-Torishima; Myojinsho; Izu-Torishima; Ioto; Fukutoku-Oka-no-Ba; Shiretoko-Iozan	Miyakejima; Akan	Nikko-Shiranesan; Nasudake; Azumayama; Hakkodasan	Asosan; Izu-Oshima		
UNCLASSIFIED	**U – HHR**	**Sumisujima**; **Nishinoshima**; **Kaitoku Seamount; Minami-Hiyoshi**; **Fukujin**; **Kasuga; Ahyi; Supply Reef; Asuncion; Agrigan;** Guguan; **South Sarigan Seamount**	**Submarine Volcano NNE of Iriomotejima**; Yokoate-jima; **Nakanoshima**; **Kita-Ioto**; **Kita-Fukutokutai; Oshima-Oshima; Ruby; NW Rota-1**	**Esan**; Taisetsuzan; Maruyama; Unnamed (281030)	**Ontakesan**; **Midagahara**; Hiuchigatake	**Kujusan**; **Adatarayama**; **Iwatesan**; **Osorezan**; Kuttara; Kueishantao	**Izu-Tobu**	
	U- HR	Alamagan	Kuchinoshima; Mikurajima	Megata; **Niijima**; **Kozushima**; Rishirizan	Abu; Sanbesan; Norikuradake; Numazawa; Hachimantai; Toshima; Niseko; Yoteizan; Kussharo	Fukue; Yokodake; Myokosan; Nantai; Omanago Group; Takaharayama; Naruko	Yonemaru-Sumiyoshiike; Yufu-Tsurumi; **Hakoneyama;** Harunasan	Tatun Group
	U-NHHR	**Sofugan; Suiyo Seamount; Mokuyo Seamount; Sarigan; Doyo Seamount; Kaikata Seamount;** Unnamed; **Nikko**; Minami Kasuga; NW Eifuku; Daikoku; Tenchozan; Unnamed (281010); Unnamed (281011); Zengyu; Unnamed (284138); Unnamed (284139); Maug Islands; **Zealandia Bank**	Akuseki-jima; Kogaja-jima; Kurose Hole; Kita-Bayonnaise; Unnamed (281020); East Diamante; **Esmeralda Bank**; Forecast Seamount; Seamount X	Shikaribetsu Group	Oki-Dogo; Washiba-Kumonotaira; Unnamed (281040)	Shiga; Akagisan; Hijiori		
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 8.4 Identity of the volcanoes in this region in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'Cassified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

Population Exposure Index

Number of Volcanoes	Population Exposure Index
1	7
8	6
26	5
31	4
13	3
29	2
35	1

Table 8.5 The number of volcanoes in Japan, Taiwan and the Marianas classed in each PEI category.

Risk Levels

Number of Volcanoes	Risk Level
11	III
17	II
18	I
97	Unclassified

Table 8.6 The number of volcanoes in the Japan, Taiwan and Marianas region classified at each Risk Level.

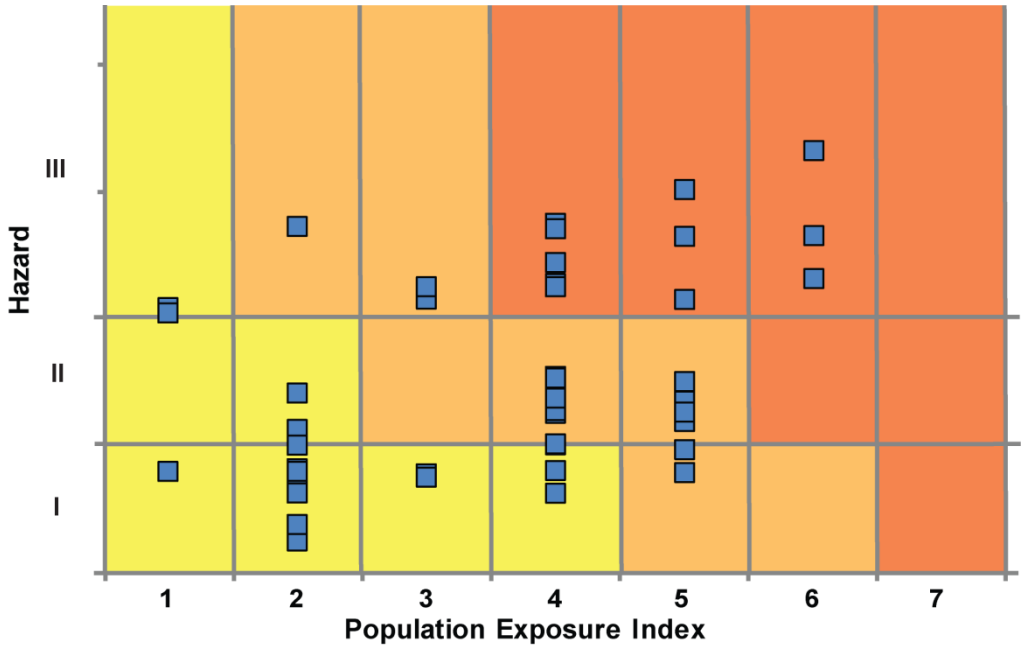

Figure 8.3 Distribution of the classified volcanoes of this region across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

Regional Monitoring Capacity

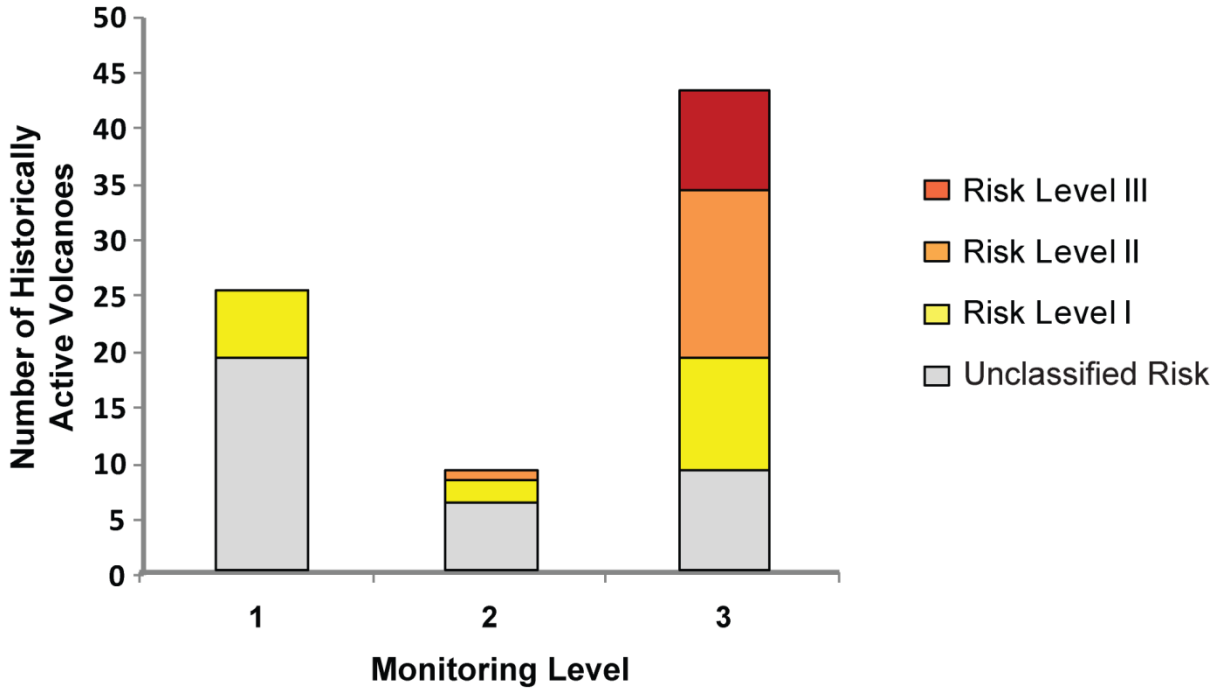

Figure 8.4 The monitoring and risk levels of the historically active volcanoes in Taiwan. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

Japan

Description

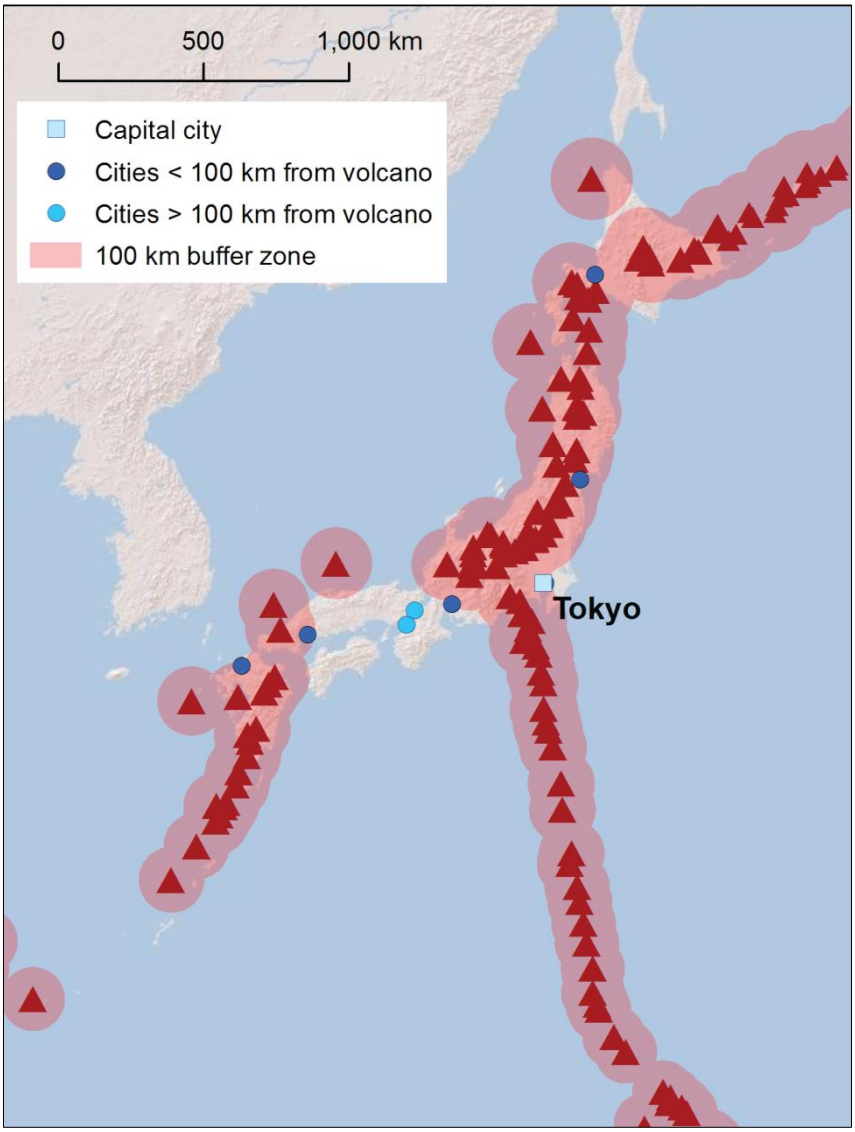

Figure 8.5 Distribution of volcanoes. The capital and largest cities in Japan are shown.

130 Holocene volcanoes are listed in Volcanoes of the World 4.0 as located throughout the islands of Japan. The subduction of the Pacific Plate beneath the Eurasian and Philippine Plates has given rise to extensive volcanism, with a range of volcano types. Subaerial volcanism is dominated by andesitic stratovolcanoes, complexes and calderas, and extensive submarine volcanism occurs throughout the Izu-Ogasawara and Ryuku Islands.

The current listing of volcanoes in VOTW4.0 differs from that of the Geological Survey of Japan and Japan Meteorological Agency (JMA), who consider 110 volcanoes to have had Holocene activity. The most recent activity at the remaining volcanoes is considered to have been Pleistocene in age. Some

discrepancies are present in the classification and naming of the volcanoes between the two datasets. Here, for consistency and reproducibility we continue to use the VOTW4.0 dataset.

Japan has an extensive Pleistocene record of large explosive eruptions, with 91 volcanoes recorded in LaMEVE with eruptions of VEI/M≥4. The largest recorded Pleistocene eruption was the M8.4 Aso 4 eruption of about 90,000 years ago, which produced extensive air fall and pyroclastic flows which covered much of Kyushu.

VOTW4.22 records Holocene activity at 102 volcanoes with 1,455 eruptions of VEI 0 to 7. The remaining volcanoes having activity of suspected though unconfirmed Holocene age. This size range demonstrates the range in activity in Japan, from small events to very large explosive eruptions. About 8% of eruptions here are recorded at VEI ≥4. About 11% of eruptions have records of producing pyroclastic flows. However, most commonly, small eruptions of VEI 0 – 2 are recorded. The largest Holocene eruption occurred about 7,000 years ago with the eruption of the Akahoya tephra from Kikai caldera, located south of Kyushu. This eruption produced pyroclastic flows which travelled 100 km across the sea to Kyushu.

Of the Holocene record, about 60% of the eruptions have been recorded post-1500 AD, with 846 historic eruptions of VEI 0 to 5 from 72 volcanoes. A smaller percentage of these eruptions are VEI ≥4, with about 3% being classed as such. This reflects both the longer recurrence intervals for eruptions of this size and the preservation of large deposits preferentially to small. Five VEI 5 eruptions have occurred historically, including one at Fuji in 1707, which deposited ash in nearby Tokyo.

In total, throughout Japan about 50% of the population live within 100 km of one or more Holocene volcano. The size of the local population varies at each volcano, with about equal numbers of volcanoes having small, moderate and high PEI values. The hazards are also variable. Fatalities are recorded in about 9% of historical eruptions, although none have been recorded since the 1990s.

The Japan Meteorological Agency (JMA) is the primary volcano monitoring institute in Japan. The JMA has worked with local governments to consider volcano disaster prevention measures and has implemented alert levels. The Coordinating Committee for Prediction of Volcanic Eruption (CCPVE) selected 47 volcanoes which required improvements to the monitoring and observation systems and is undertaking these improvements. Continuous monitoring is now in place at all 47 volcanoes using dedicated seismic and deformation networks, in addition to other techniques. Individual observatories of Usu Volcano Observatory, Shimabara Volcano Observatory, Asama Volcano Observatory, Kirishima Volcano Observatory, Aso Volcano Observatory, Sakurajima Volcano Observatory and Izu-Oshima Volcano Observatory have been set up by Universities. Multiple research and monitoring institutions work on the volcanoes of Japan, including the JMA, Volcanological Society of Japan, Universities (Tohoku University, Hokkaido University, Earthquake Research Institute in University of Tokyo, Kyoto University, Kyushu University etc), National Organisations (National Research Institute for Earth Science and Disaster Prevention, Japan Coast Guard, Geological Survey of Japan, etc) and other local institutes.

Monitoring data from each volcano is sent to the Volcanic Observations and Information Center in the JMA, where Volcanic Warnings are issued. Warnings are given for residential areas, non-residential areas near the crater and around the crater. These warnings include descriptions of the

observed monitoring data and activity. Warnings are provided to the Japan Coast Guard, the Ministry of Land, Infrastructure, Transport and Tourism, the media, emergency services, the NTT (Nippon Telegraph and Telephone Corporation), prefectural offices and the public. Volcanic Alert Levels of 1 to 5 are given with clear descriptions of appropriate action to take. These Levels and the warnings given depend on the level of activity and the area affected. The regional VAAC is also notified when appropriate.

See also:

Japan Meteorological Agency Volcanic Warnings:
/www.data.jma.go.jp/svd/vois/data/tokyo/STOCK/kaisetsu/English/level.html

National Research Institute for Earth Science and Disaster Prevention: www.bosai.go.jp/e/

National Catalogue of the Active Volcanoes in Japan, 4th Edition (JMA):
www.data.jma.go.jp/svd/vois/data/tokyo/STOCK/souran_eng/menu.htm

GSJ Quaternary volcano database: gbank.gsj.jp/volcano/Quat_Vol/volcano_list.html

Volcano Facts

Number of Holocene volcanoes	130
Number of Pleistocene volcanoes with M≥4 eruptions	95
Number of volcanoes generating pyroclastic flows	51
Number of volcanoes generating lahars	39
Number of volcanoes generating lava flows	42
Number of fatalities caused by volcanic eruptions	?>22,770
Tectonic setting	Subduction zone
Largest recorded Pleistocene eruption	The M8.4 eruption 4 of Aso, which occurred about 90,000 years ago.
Largest recorded Holocene eruption	The eruption of the Akahoya tephra from Kikai volcano at 7330 BP is recorded as M8.1. The volume of this event indicates that the magnitude should be recalculated at M7.2, however this still would be classed as the largest eruption in Japan in the Holocene.
Number of Holocene eruptions	1,455 confirmed eruptions.
Recorded Holocene VEI range	0 -7 and unknown

Number of historically active volcanoes	72
Number of historical eruptions	846

Number of volcanoes	Primary volcano type	Dominant rock type
13	Caldera(s)	Andesitic (9), Dacitic (2), Rhyolitic (2)
77	Large cone(s)	Andesitic (57), Basaltic (17), Dacitic (1), Unknown (2)
7	Lava dome(s)	Andesitic (4), Dacitic (1), Rhyolitic (2)
8	Shield(s)	Andesitic (5), Basaltic (2), Dacitic (1)
4	Small cone(s)	Andesitic (1), Basaltic (2)
21	Submarine	Andesitic (8), Basaltic (5), Dacitic (3), Rhyolitic (2), Unknown (3)

Table 8.7 The number of volcanoes in Japan, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	127,157,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	30,660
Gross National Income (GNI) per capita (2005 PPP $)	32,545
Human Development Index (HDI) (2012)	0.912 (Very High)

Population Exposure

Capital city	Tokyo
Distance from capital city to nearest Holocene volcano	83.3 km
Total population (2011)	127,469,543
Number (percentage) of people living within 10 km of a Holocene volcano	622,818 (<1%)
Number (percentage) of people living within 30 km of a Holocene volcano	9,381,463 (7.4%)
Number (percentage) of people living within 100 km of a Holocene volcano	61,363,766 (48.1%)

Ten largest cities, as measured by population and their population size (2010, from UNdata data.un.org):

Tokyo	8,945,695
Yokohama	3,688,773

Osaka	2,665,314
Nagoya	2,263,894
Sapporo	1,913,545
Kobe	1,544,200
Kyoto	1,474,015
Fukuoka	1,463,743
Kawasaki	1,425,512
Saitama	1,222,434

Infrastructure Exposure

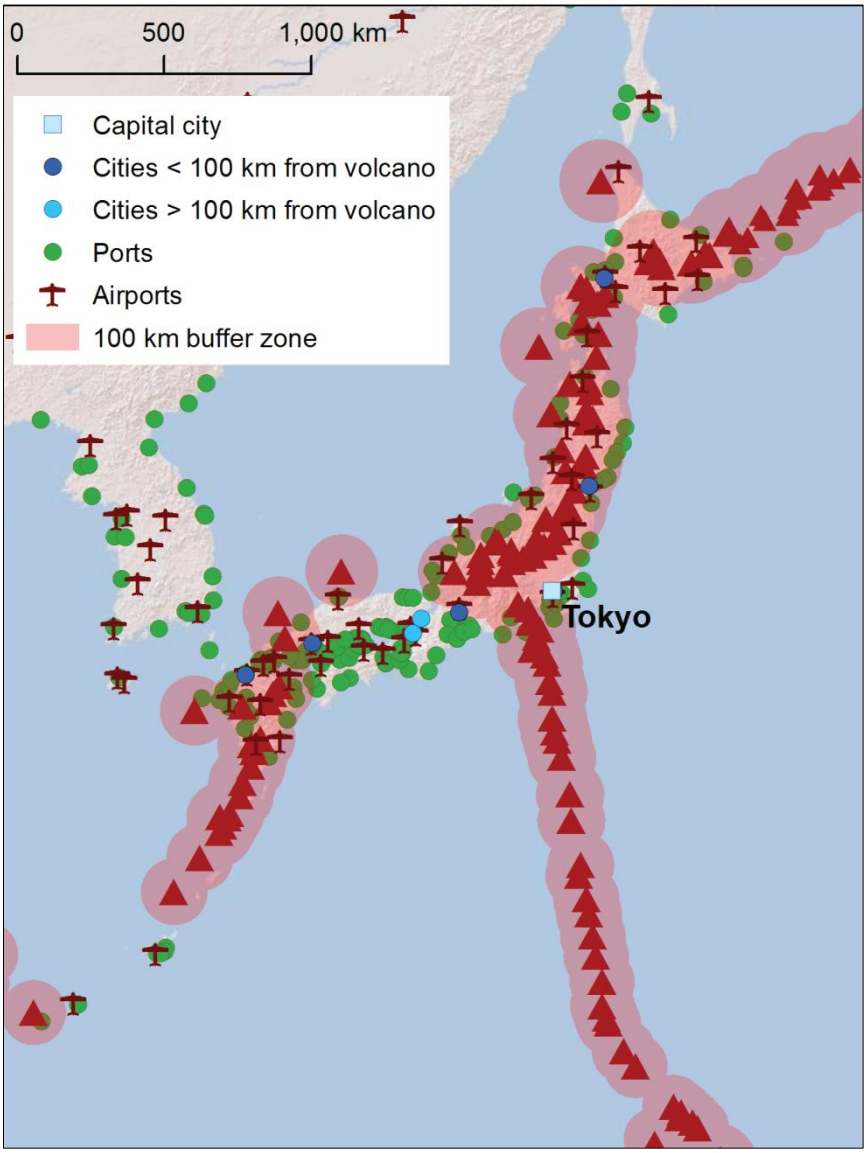

Figure 8.6 The location of the volcanoes in Japan and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Number of airports within 100 km of a volcano	30

Number of ports within 100 km of a volcano	99
Total length of roads within 100 km of a volcano (km)	41,982
Total length of railroads within 100 km of a volcano (km)	7,097

Holocene volcanoes are distributed throughout Japan, placing large parts of the country within 100 km of these volcanoes. Many of the largest cities in Japan, including the capital, Tokyo, lie within 100 km of one or more volcanoes. This means that most of the critical infrastructure is exposed, including nearly 100 ports, 30 airports including international airports, and a very extensive road and rail network linking the islands.

Hazard, Uncertainty and Exposure Assessments

There are varying levels of data available in the eruption records of Japan's volcanoes. About 40% of the volcanoes here have enough data in their records to permit the calculation of the hazard, and these volcanoes are classified across all three hazard levels, with approximately equal numbers of volcanoes in each level.

Over 60% of the volcanoes have large uncertainties associated with the classification of the Hazard level due to incomplete or sparse eruption records, and these are therefore unclassified. Indeed, about a third of the unclassified volcanoes have no records of confirmed eruptions during the Holocene, though of these, six have had episodes of apparent unrest since 1900 AD suggestive of active systems. A further third of the unclassified volcanoes have Holocene records of eruptions before 1500 AD, and the remaining third have had historical activity, including 15 volcanoes with eruptions since 1900 AD. Twelve of the unclassified volcanoes have Holocene records of large magnitude, VEI ≥4 eruptions.

The PEI ranges from low to high, with approximately equal numbers of low PEI, moderate PEI and high PEI volcanoes. Some of the volcanoes with the highest hazard also have the highest PEI. The classified volcanoes categorise in all three risk levels, with 11 classed at Risk Level III. Sakurajima (Aira), with the highest Hazard level in Japan also has a very high local population, with over 110,000 living within 10 km, making this a Risk Level III volcano.

Table 8.8 (next page): Identity of Japan's volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'Classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in ***bold*** *have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

CLASSIFIED	**Hazard III**		Aogashima	Tokachidake; Rausudake	Hakusan; Niigata-Yakeyama; Towada; Hachijojima; Mashu	Fujisan; Hokkaido-Komagatake; Toya (Usu)	Aira; Unzendake; Shikotsu	
	Hazard II		Suwanosejima; Kuchinoerabujima; Kikai; Chachadake [Tiatia]; Etorofu-Yakeyama [Grozny Group]		Kirishimayama; Yakedake; Kurikomayama; Chokaisan; Akita-Komagatake; Akita-Yakeyama; Iwakisan	Ibusuki Volcanic Field; Asamayama; Kusatsu-Shiranesan; Bandaisan; Zaozan		
	Hazard I		Io-Torishima; Myojinsho; Izu-Torishima; Ioto; Fukutoku-Oka-no-Ba; Shiretoko-Iozan; Moyorodake [Medvezhia]	Miyakejima; Akan	Nikko-Shiranesan; Nasudake; Azumayama; Hakkodasan	Asosan; Izu-Oshima		
UNCLASSIFIED	**U – HHR**	**Sumisujima**; **Nishinoshima**; **Kaitoku Seamount;** **Minami-Hiyoshi**; **Fukujin**; **Kasuga**	**Submarine Volcano NNE of Iriomotejima**; Yokoate-jima; **Nakanoshima**; **Kita-Ioto**; **Kita-Fukutokutai; Oshima-Oshima;** Tomariyama [Golovnin]; **Raususan [Mendeleev];** Etorofu-Atosanupuri [Atosanupuri]; Sashiusudake [Baransky]; Chirippusan [Chirip]	**Esan**; Taisetsuzan; Maruyama	**Ontakesan**; **Midagahara**; Hiuchigatake	**Kujusan**; **Adatarayama**; **Iwatesan**; **Osorezan**; Kuttara	**Izu-Tobu**	
	U- HR		Kuchinoshima; Mikurajima; Moekeshiwan [Lvinaya Past]	Megata; **Niijima**; **Kozushima**; Rishirizan	Abu; Sanbesan; Norikuradake; Numazawa; Hachimantai; Toshima; Niseko; Yoteizan; Kussharo	Fukue; Yokodake; Myokosan; Nantai; Omanago Group; Takaharayama; Naruko	Yonemaru-Sumiyoshiike; Yufu-Tsurumi; **Hakoneyama;** Harunasan	
	U- NHHR	**Sofugan; Suiyo Seamount; Mokuyo Seamount; Doyo Seamount; Kaikata Seamount;** Unnamed; **Nikko**; Minami Kasuga; NW Eifuku; Daikoku; Tenchozan; Odamoisan [Tebenkov]	Akuseki-jima; Kogaja-jima; Kurose Hole; Kita-Bayonnaise; Ruruidake [Smirnov]; Berutarubesan [Berutarube]; Nishihitokappuyama [Bogatyr Ridge]; Unnamed (290061); Rucharuyama [Golets-Tornyi Group]; Rakkibetsudake [Demon]	Shikaribetsu Group	Oki-Dogo; Washiba-Kumonotaira	Shiga; Akagisan; Hijiori		
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

Volcano	Population Exposure Index	Risk Level
Aira	6	III
Unzendake	6	III
Shikotsu	6	III
Fujisan	5	III
Hokkaido-Komagatake	5	III
Toya	5	III
Ibusuki Volcanic Field	5	II
Asosan	5	II
Asamayama	5	II
Kusatsu-Shiranesan	5	II
Bandaisan	5	II
Zaozan	5	II
Izu-Oshima	5	II
Hakusan	4	III
Niigata-Yakeyama	4	III
Towada	4	III
Hachijojima	4	III
Mashu	4	III
Kirishimayama	4	II
Yakedake	4	II
Kurikomayama	4	II
Chokaisan	4	II
Akita-Komagatake	4	II
Akita-Yakeyama	4	II
Iwakisan	4	II
Nikko-Shiranesan	4	I
Nasudake	4	I
Azumayama	4	I
Hakkodasan	4	I
Tokachidake	3	II
Rausudake	3	II
Miyakejima	3	I
Akan	3	I
Aogashima	2	II
Chachadake [Tiatia]	2	I
Etorofu-Yakeyama [Grozny Group]	2	I
Fukutoku-Oka-no-Ba	2	I
Io-Torishima	2	I
Ioto	2	I
Izu-Torishima	2	I
Kuchinoerabujima	2	I
Kikai	2	I
Moyorodake [Medvezhia]	2	I
Myojinsho	2	I
Shiretoko-Iozan	2	I
Suwanosejima	2	I

Table 8.9 Classified volcanoes ordered by descending Population Exposure Index (PEI). Risk levels determined through the combination of the Hazard Level and PEI are given. Risk Level I – 15 volcanoes; Risk Level II – 17 volcanoes; Risk Level III – 11 volcanoes.

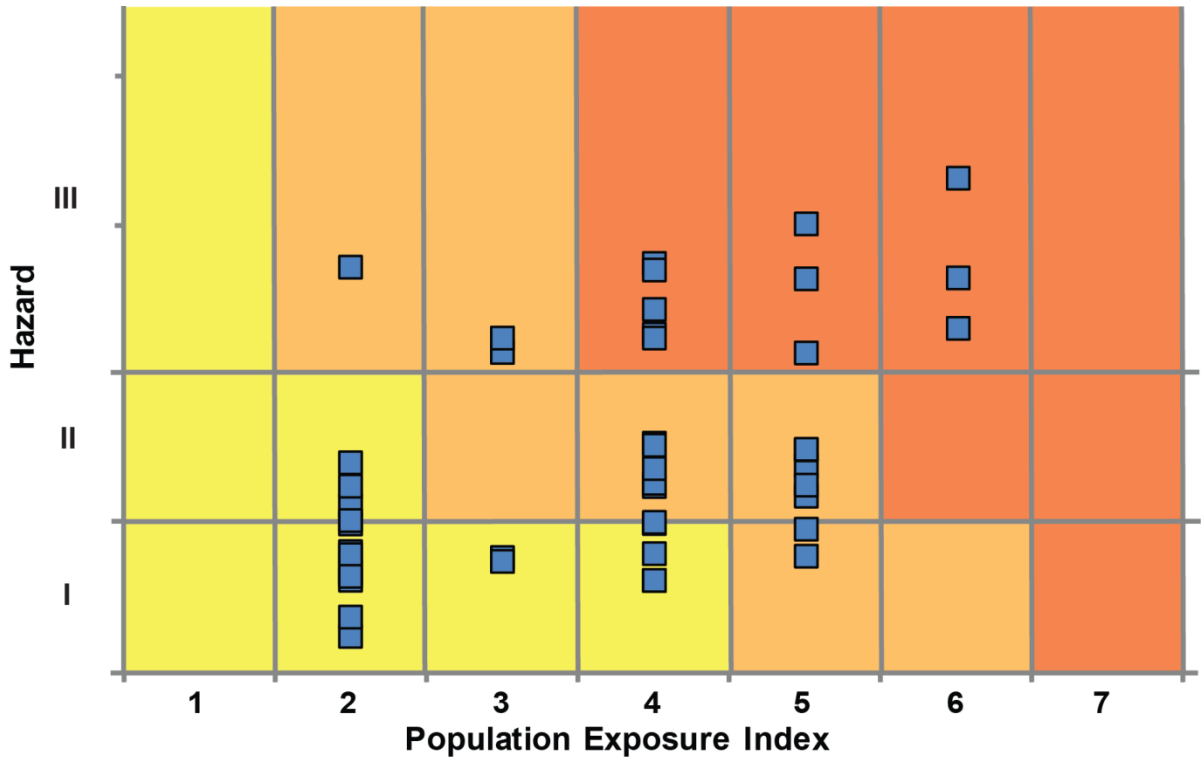

Figure 8.7 Distribution of volcanoes across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

National Capacity for Coping with Volcanic Risk

Seventy-two volcanoes have historical records of activity. These volcanoes range across the risk spectrum, with most classed as Risk Level II. Several research and monitoring institutions are active in Japan, though the JMA is the principal monitoring body. The level of monitoring varies volcano to volcano, however there is an overall trend in increased monitoring at the higher risk volcanoes. Forty-one of these volcanoes are continuously monitored by the JMA using dedicated seismic and deformation networks. A further seven volcanoes have monitoring networks located within 20 km or networks with discontinuous monitoring. JMA also continuously monitor a number of volcanoes which have a Holocene record of activity prior to 1500 AD.

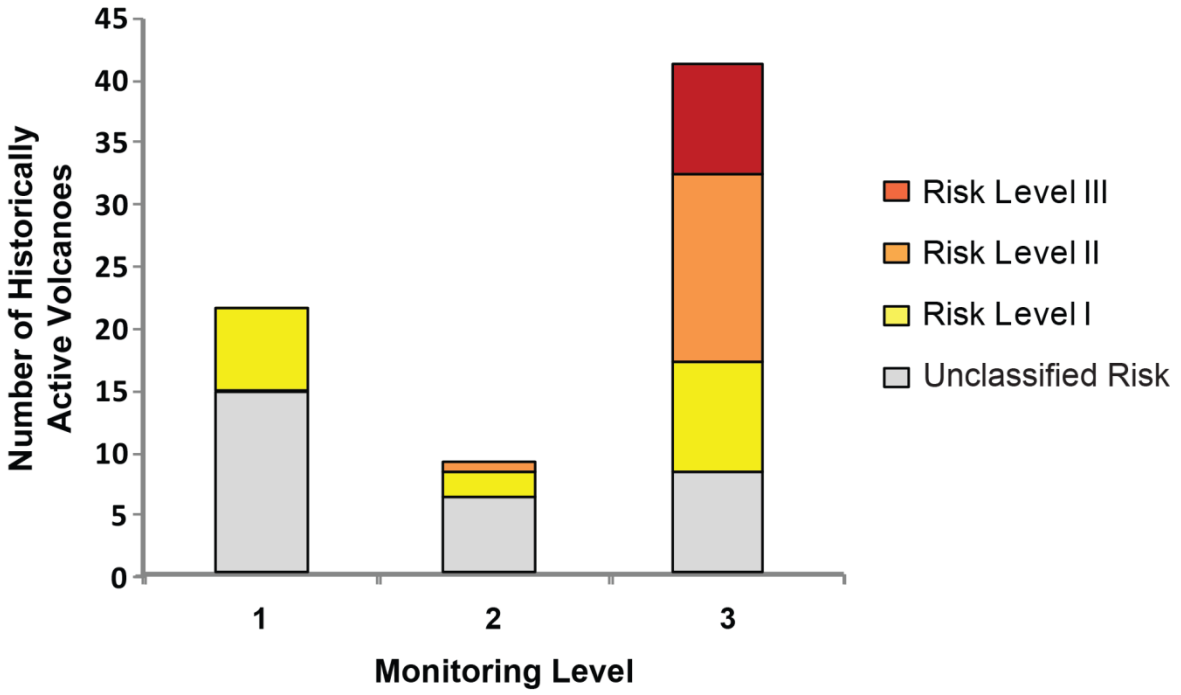

Figure 8.8 The monitoring and risk levels of the historically active volcanoes in Japan. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

N.B. The volcanoes on the Kunashir and Iturup Islands are also discussed in the separate Region 9: Kuril Islands profile.

Taiwan

Description

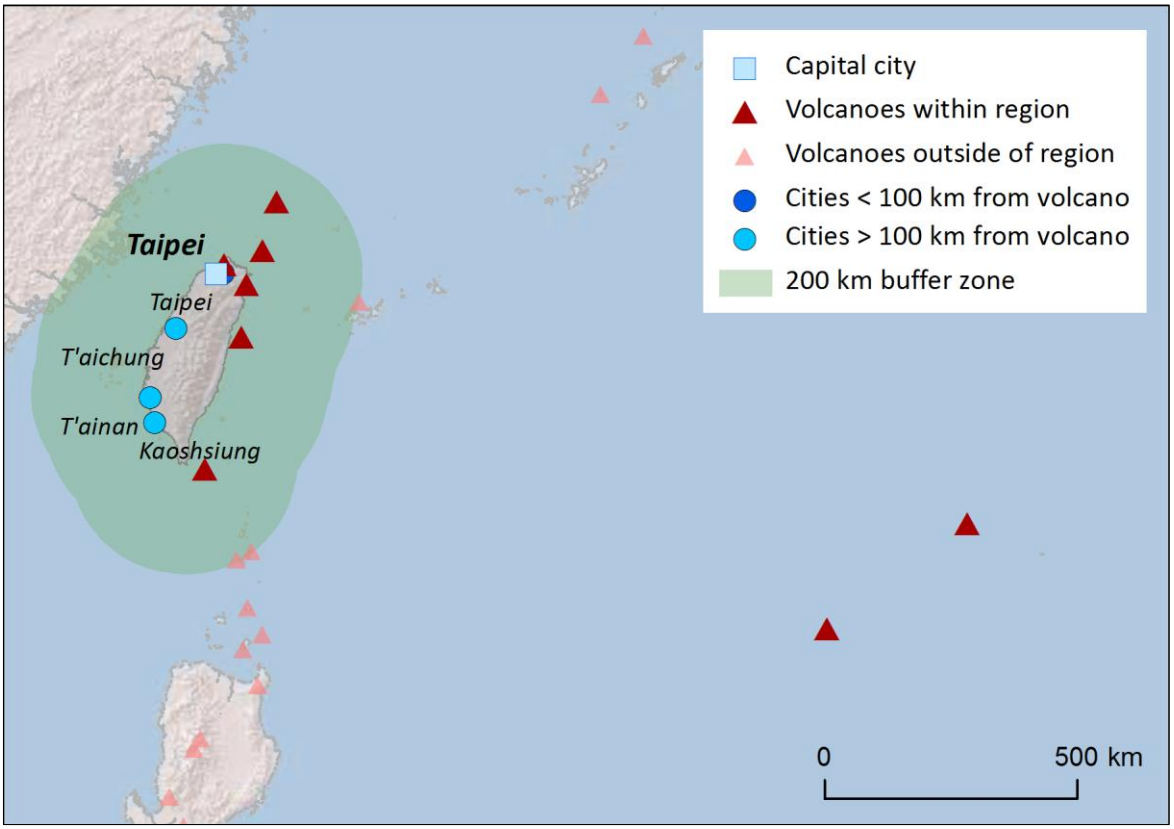

Figure 8.9 Location of Taiwan's volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Taiwan.

Eight Holocene volcanoes are located in Taiwan: the Tatun Group volcano on mainland Taiwan; Kueishantao and another three volcanoes near the north-east coast; and one volcano off the south-east coast. Volcanism here is due to the subduction of the Philippine Plate under the Eurasian Plate.

The Tatun Group is a complex of dominantly andesitic lava domes. Kueishantao is also dominantly andesitic, and is the only stratovolcano in Taiwan. The other six Holocene volcanoes are submarine of unknown composition.

Of the eight Holocene volcanoes, only three have confirmed Holocene records of eruptions, the remaining are suspected of having Holocene age activity. Tatun Group has a dated VEI 1 eruption of 4100 BC, whilst Kueishantao and an unnamed submarine volcano have historical records of eruptions in 1785 and 1853 respectively. The largest recorded eruption was the VEI 2 eruption in 1853.

Although most of Taiwan's volcanoes are located offshore, a considerable percentage of the population resides in areas proximal to Taiwan's Holocene volcanoes. This is due to the location of the Tatun Group, situated within 10 km of the capital, Taipei.

The sparse Holocene eruption record in Taiwan means that assessment of hazard here is associated with large uncertainties, and focussed research is required to more fully understand the eruptive histories, particularly of the subaerial features. Indeed, in response to this need the Taiwan Volcano Observatory (TVO) was founded and became operational in October 2011. The TVO has primary responsibility for the Tatun Group volcano, where the observatory is situated, and Kueishantao. Monitoring is undertaken at both these volcanoes, with an extensive multi-system network of dedicated instrumentation and research at Tatun Group.

The TVO is supported by the Ministry of Science and Technology and is funded by the Taiwan government. At present risk assessments are being developed and the TVO participate in managing and mitigating the risks.

See also:

Taiwan Volcano Observatory – Tatun, tec.earth.sinica.edu.tw/TVO/free.php?link=sciedu/knowvol

Volcano Facts

Number of Holocene volcanoes	6 with 2 unconfirmed
Number of Pleistocene volcanoes with M≥4 eruptions	-
Number of volcanoes generating pyroclastic flows	-
Number of volcanoes generating lahars	-
Number of volcanoes generating lava flows	1
Number of fatalities caused by volcanic eruptions	-
Tectonic setting	Subduction zone (6), Rift zone (1)
Largest recorded Pleistocene eruption	-
Largest recorded Holocene eruption	The VEI 2 eruption of an unnamed volcano in 1853.
Number of Holocene eruptions	3 confirmed eruptions. 5 uncertain eruptions, 1 discredited.
Recorded Holocene VEI range	0 – 2
Number of historically active volcanoes	2
Number of historical eruptions	2

Number of volcanoes	Primary volcano type	Dominant rock type
1	Large cone(s)	Andesitic (1)
1	Lava dome(s)	Andesitic (1)
6	Submarine	Unknown (6)

Table 8.10 The number of volcanoes in Taiwan, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2014) (National Statistics, Republic of China[1])	23,379,594
Gross Domestic Product (GDP) per capita (2013, CIA[2])	39,600
Gross National Income (GNI) per capita (2005 PPP $)	
Human Development Index (HDI) (2011[3])	0.882

Population Exposure

Capital city	Taipei
Distance from capital city to nearest Holocene volcano	<10 km
Total population (2011)	23,071,779
Number (percentage) of people living within 10 km of a Holocene volcano	612,157 (2.7%)
Number (percentage) of people living within 30 km of a Holocene volcano	7,763,020 (33.7%)
Number (percentage) of people living within 100 km of a Holocene volcano	10,878,326 (47.2%)

Infrastructure Exposure

Number of airports within 100 km of a volcano	3

[1] eng.stat.gov.tw/mp.asp?mp=5
[2] www.cia.gov/library/publications/the-world-factbook/geos/tw.html
[3] 16124371.pdf

Number of ports within 100 km of a volcano	4
Total length of roads within 100 km of a volcano (km)	2,415
Total length of railroads within 100 km of a volcano (km)	548

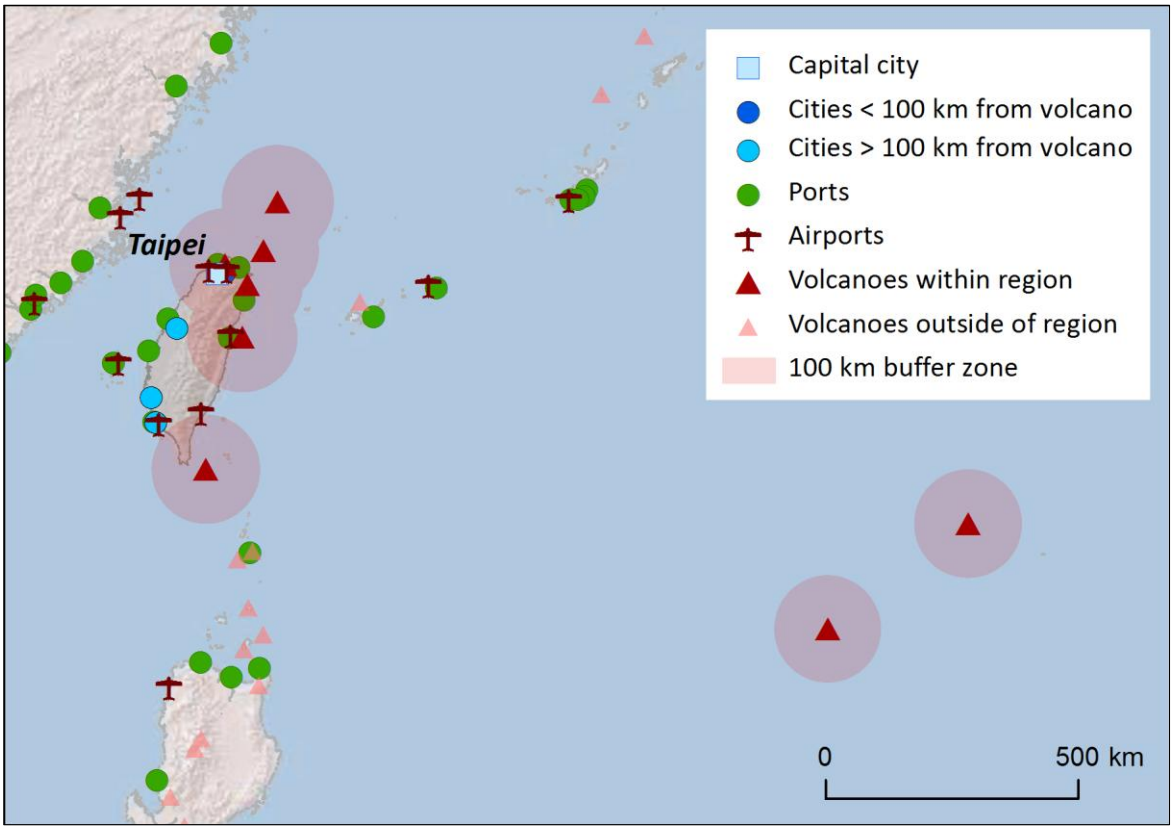

Figure 8.10 The location of Taiwan's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

The volcanoes in Taiwan are concentrated in the north, where the capital Taipei lies within 100 km. Indeed it is less than 10 km from Taipei to the Tatun Group volcano. Other large cities and considerable infrastructure are exposed in the north, including airports and ports. Large cities in the south are also within 100 km of an unnamed volcano off the coast of Taiwan. An extensive road and rail network is exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

The eruption records for the volcanoes in Taiwan are sparse and this prevents hazard assessment without significant associated uncertainties. The volcanoes here are therefore unclassified. Indeed, of the eight volcanoes, just three have a Holocene eruption record each with just one eruption. Both an unnamed volcano and Kueishantao have erupted historically, whilst the last recorded eruption of Tatun Group was in 4100 BC.

The PEI ranges from low to very high in Taiwan. No volcanoes are classified by risk level due to the absence of a hazard classification, however the high local population around the Tatun Group makes this a PEI 7 volcano, which indicates high risk.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I							
UNCLASSIFIED	**U – HHR**			Unnamed (281030)		Kueishantao		
	U- HR							Tatun Group
	U-NHHR	Unnamed (281010); Unnamed (281011); Zengyu	Unnamed (281020)		Unnamed (281040)			
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 8.11 Identity of Taiwan's volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'Classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.National Capacity for Coping with Volcanic Risk*

Two volcanoes have historical activity: an unnamed submarine volcano and Kueishantao. The Taiwan Volcano Observatory principally monitors Tatun Group (active in the Holocene) and Kueishantao. The location of the Tatun Group volcano with a large proximal population and the dominance of monitoring activities here indicates that monitoring resources are focussed on volcanoes of highest risk.

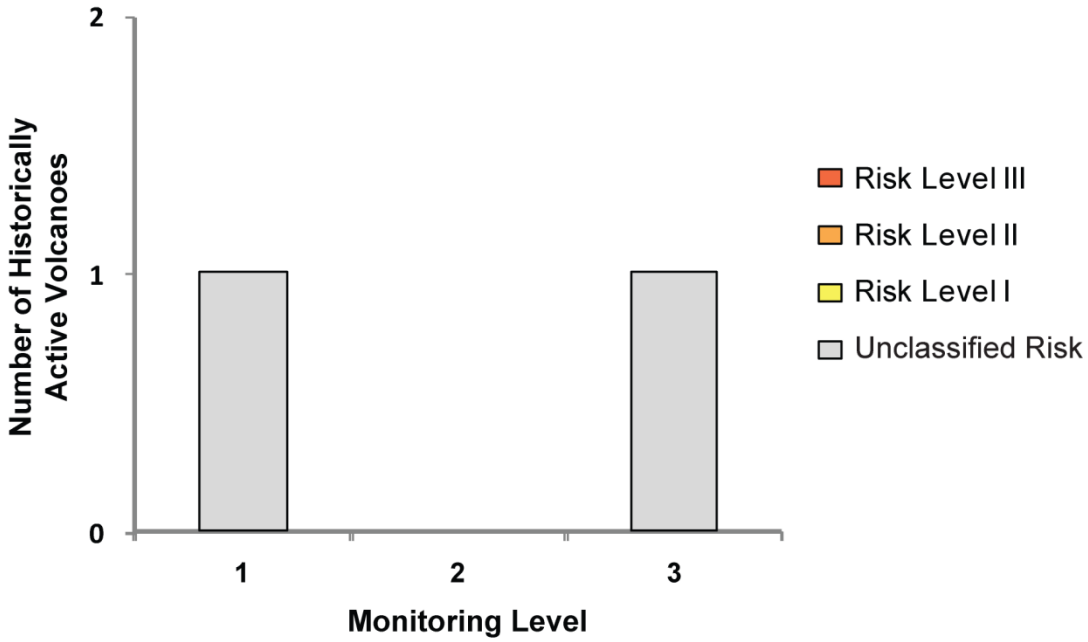

Figure 8.11 The monitoring and risk levels of the historically active volcanoes in Taiwan. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

USA – Mariana Islands

For further USA profiles see Region 4 for American Samoa, Region 11 for Alaska, Region 12 for the contiguous states, Region 13 for Hawaii.

Description

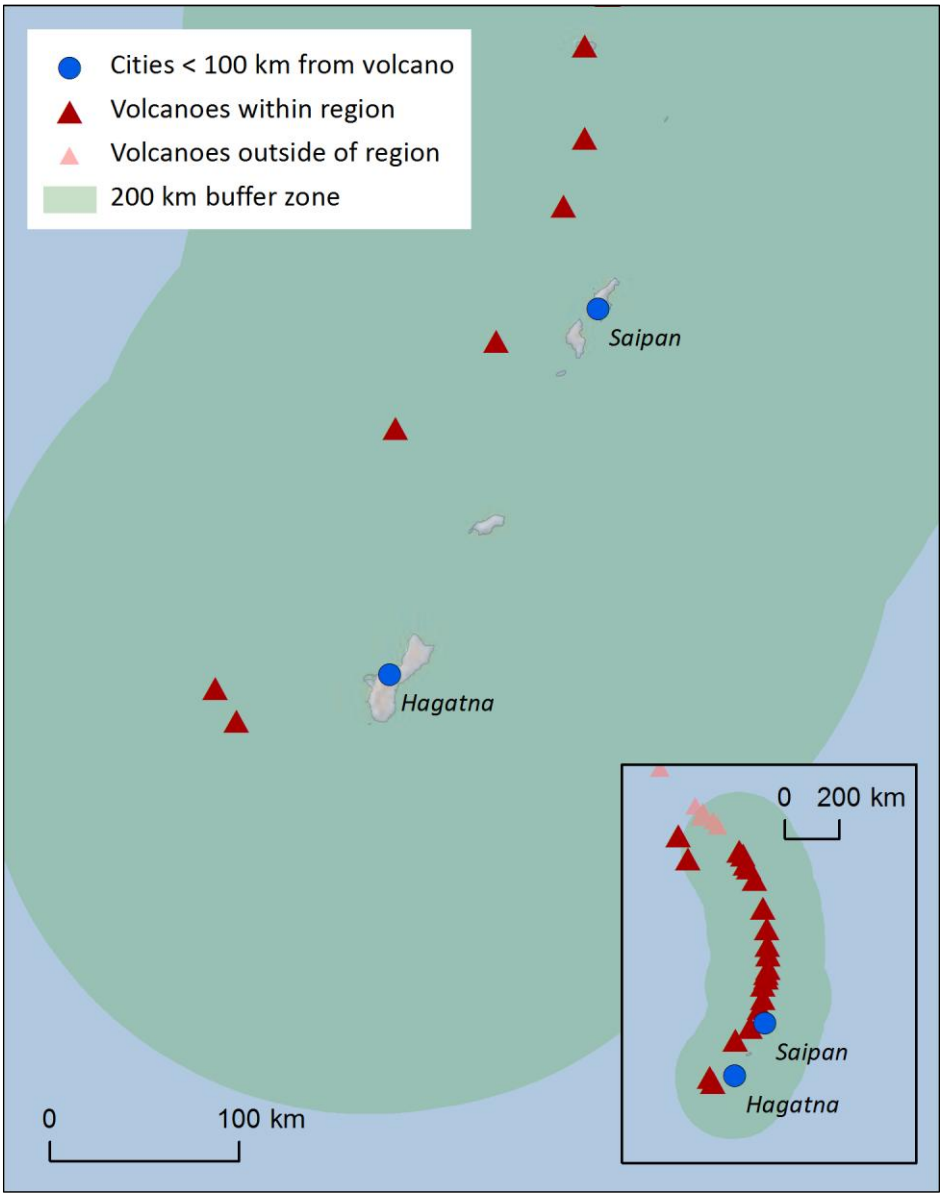

Figure 8.12 Location of the Marianas Island volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect the Marianas Islands.

Twenty-one Holocene volcanoes are located in the Marianas Islands, located at the southern end of the Izu-Marianas arc. Volcanism here is due to the subduction of the Pacific Plate beneath the Philippine plate, producing the ocean island arc. Eleven volcanoes are submarine, while all subaerial

volcanoes are stratovolcanoes. Basaltic to dacitic rock types are present, with basalts and andesites being most common.

Fifty-two confirmed Holocene eruptions are recorded in the Marianas, of VEI 0 to 4, indicating a range of activity from mild to large explosive events. Of these, forty-nine are recorded historically, all but one since 1800, demonstrating that the geological record is sparse and that activity here prior to this time is poorly understood. Pyroclastic flows are recorded in four historical eruptions (8% of events).

The population of the Marianas is sparse, with the biggest settlements being restricted to the largest islands to the east of the volcanic chain. The population within 30 km of the Holocene volcanoes is therefore just 1, however extending the radii to 100 km encompasses the whole population of the Marianas. Evacuations have been called during eruptions of Agrigan, Pagan and South Sarigan Seamount as recently as 2010. The 2010 eruption of South Sarigan Seamount produced an eruption column to 12km above the surface.

The CNMI (Commonwealth of the Northern Mariana Islands) Emergency Management Office, the Southern Methodist University and the Alaska and Hawaii Volcano observatories of the U.S. Geological Survey have been collaborating to establish monitoring networks in the Mariana Islands and to assess the volcanic hazards. Telemetered seismic stations are located on the historically active Anatahan and Pagan volcanoes and the Holocene Sarigan volcano, and infrasound arrays are used to detect explosive activity at the other Mariana Island volcanoes. Satellite monitoring is also undertaken.

See also:

Hawaii Volcano Observatory: hvo.wr.usgs.gov/volcanowatch/archive/2003/03_09_18.html

USGS Volcano Hazards Program: volcanoes.usgs.gov/vhp/observatories.php

USGS Northern Mariana Islands: volcanoes.usgs.gov/nmi/activity/

Volcano Facts

Number of Holocene volcanoes	21
Number of Pleistocene volcanoes with M≥4 eruptions	-
Number of volcanoes generating pyroclastic flows	3
Number of volcanoes generating lahars	1
Number of volcanoes generating lava flows	6
Number of fatalities caused by volcanic eruptions	-
Tectonic setting	Subduction zone
Largest recorded Pleistocene eruption	-

Largest recorded Holocene eruption	The M4.5 870 AD eruption of Alamagan.
Number of Holocene eruptions	52 confirmed eruptions.
Recorded Holocene VEI range	0 – 4 and unknown
Number of historically active volcanoes	11
Number of historical eruptions	49

Number of volcanoes	Primary volcano type	Dominant rock type
10	Large cone(s)	Andesitic (6), Basaltic (4)
11	Submarine	Andesitic (2), Basaltic (4), Dacitic (1) Unknown (4)

Table 8.12 The number of volcanoes in the Marianas Islands, their volcano type classification and dominant rock type according to VOTW4.0.

Population Exposure

Capital city	Saipan
Distance from capital city to nearest Holocene volcano	25.3 km
Total population (2011)	46,050
Number (percentage) of people living within 10 km of a Holocene volcano	1 (<1%)
Number (percentage) of people living within 30 km of a Holocene volcano	1 (<1%)
Number (percentage) of people living within 100 km of a Holocene volcano	52,965 (>100%)

Infrastructure Exposure

Number of airports within 100 km of a volcano	2
Number of ports within 100 km of a volcano	4
Total length of roads within 100 km of a volcano (km)	127
Total length of railroads within 100 km of a volcano (km)	0

The Northern Marianas Islands include many small settlements, with the biggest cities on the largest islands of Guam, Rota Island, Tinian and Saipan. Much of the infrastructure is also located on these

islands, including four ports and two airports. These largest islands lie within 100 km of the volcanoes which are displaced to the west.

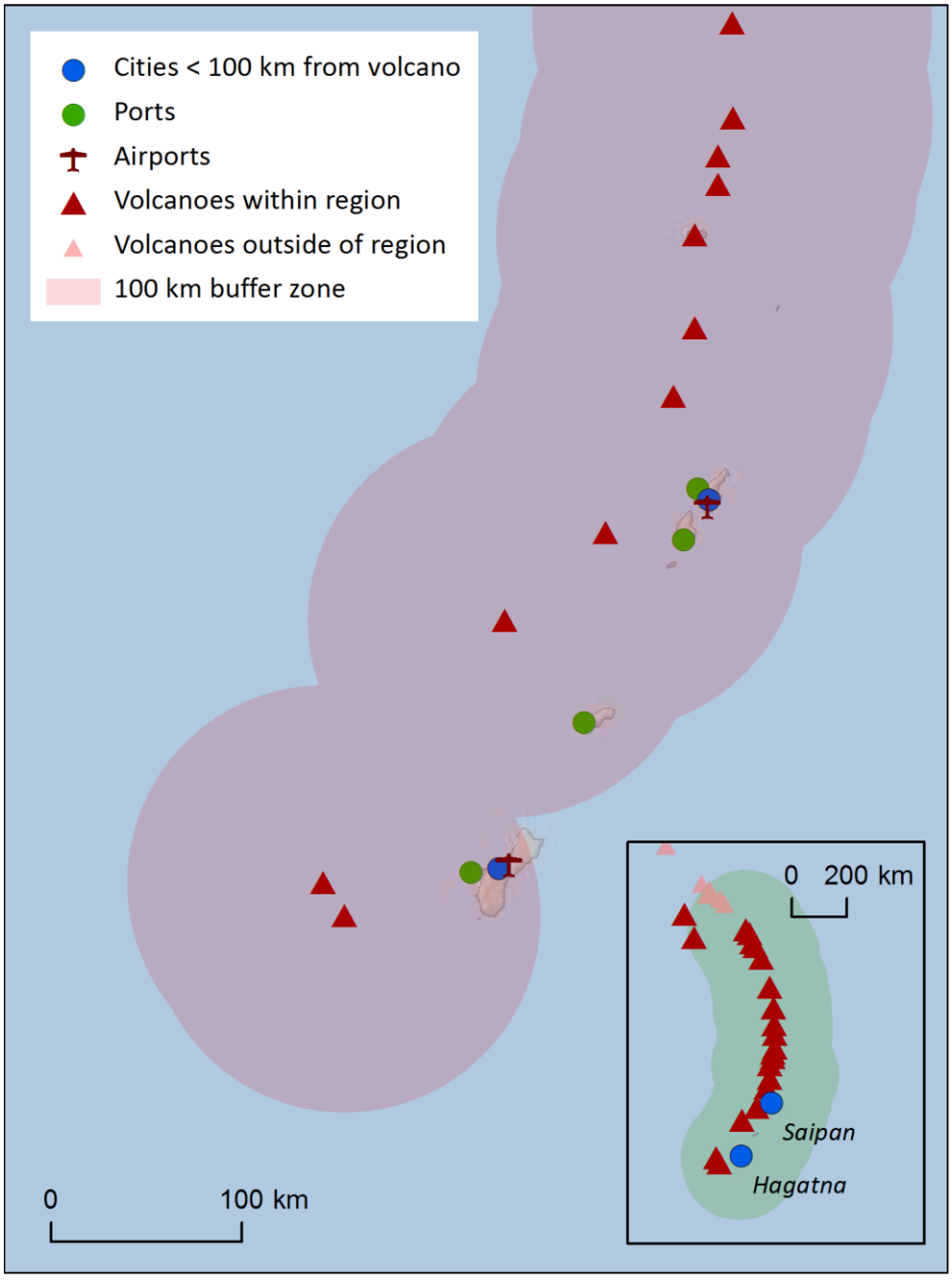

Figure 8.13 The location of CNMI's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

There are varying levels of data available in the eruption records of the volcanoes of the Marianas Islands. Indeed, out of 21 volcanoes, just three have sufficiently extensive and detailed records to have their hazard levels classified. These volcanoes, Pagan, Anatahan and Farallon de Pajaros, have

records of 40 confirmed Holocene eruptions, most of which also have an attributed size. All but one of these eruptions occurred since the 1600s. With no eruptions over VEI 2, Farallon de Pajaros is classified at Hazard Level I, whilst Anatahan and Pagan, with records of VEI 3 and 4 eruptions respectively, are ranked at Hazard Level III. These three volcanoes are classified at Risk Level I, with no local populations.

With the exception of these three volcanoes, all others are unclassified. Nine volcanoes have no Holocene eruption record, though three, Zealandia Bank, Sarigan and Esmeralda Bank, have experienced unrest since 1900 AD. Eight unclassified volcanoes have records of historical eruptions, including eruptions since 1900 at seven volcanoes.

With low proximal populations in the Marianas, including no population within 30 km at any of the volcanoes, the PEI is low at 1 and 2.

CLASSIFIED	**Hazard III**	Pagan; Anatahan						
	Hazard II							
	Hazard I	Farallon de Pajaros						
UNCLASSIFIED	**U – HHR**	**Ahyi; Supply Reef; Asuncion; Agrigan;** Guguan; **South Sarigan Seamount**	**Ruby; NW Rota-1**					
	U- HR	Alamagan						
	U-NHHR	Unnamed (284138); Unnamed (284139); Maug Islands; **Zealandia Bank; Sarigan**	East Diamante; **Esmeralda Bank**; Forecast Seamount; Seamount X					
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 8.13 Identity of the Marianas Islands' volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'Classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

Volcano	Population Exposure Index	Risk Level
Anatahan	1	I
Farallon de Pajaros	1	I
Pagan	1	I

Table 8.14 Classified volcanoes of Mariana Islands ordered by descending Population Exposure Index (PEI). Risk levels determined through the combination of the Hazard Level and PEI are given. Risk Level I – 3 volcanoes; Risk Level II – 0 volcanoes; Risk Level III – 0 volcanoes.

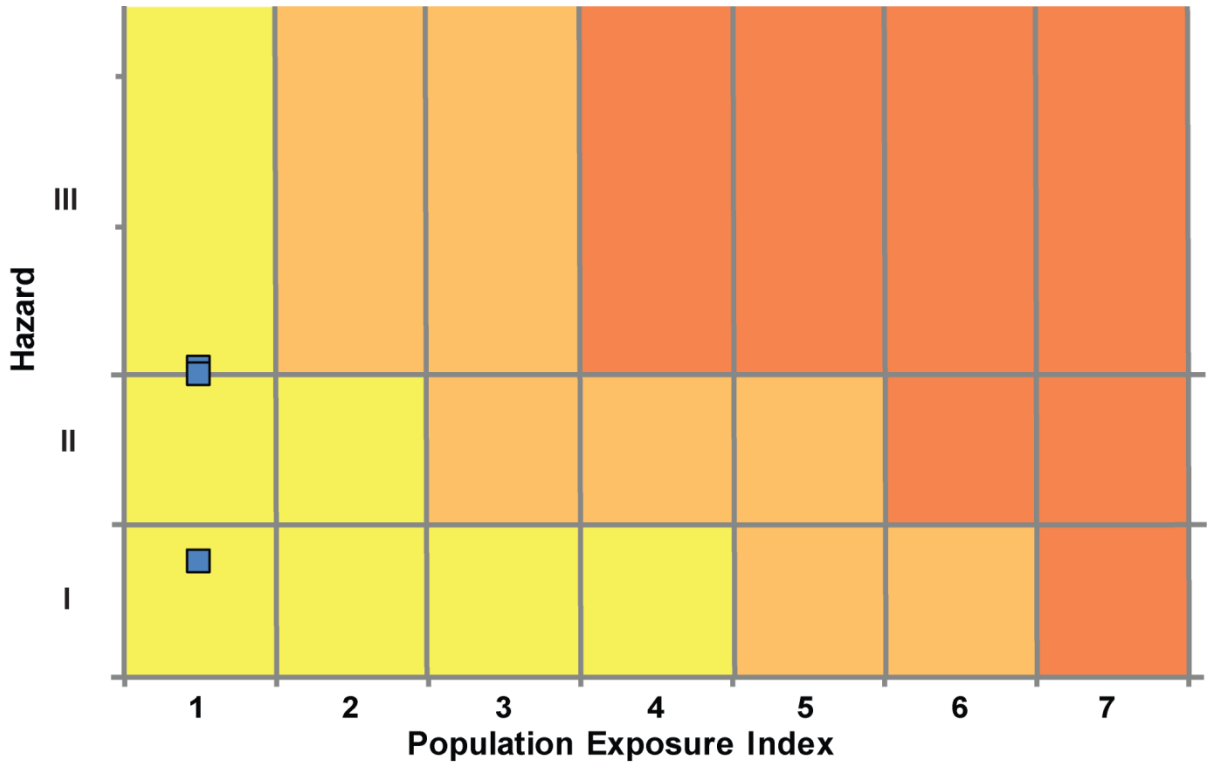

Figure 8.14 Distribution of the Marianas Islands' classified volcanoes across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

National Capacity for Coping with Volcanic Risk

The monitoring of the Marianas Island volcanoes is the responsibility of the Alaska Volcano Observatory. The USGS Northern Marianas Duty Scientist is a position that rotates between the Alaska and Hawaii Volcano Observatories. The Risk Level I Anatahan and Pagan volcanoes have dedicated seismic monitoring in place, as does the Holocene age Sarigan. Infrasound arrays are used for detection of activity at other volcanoes here.

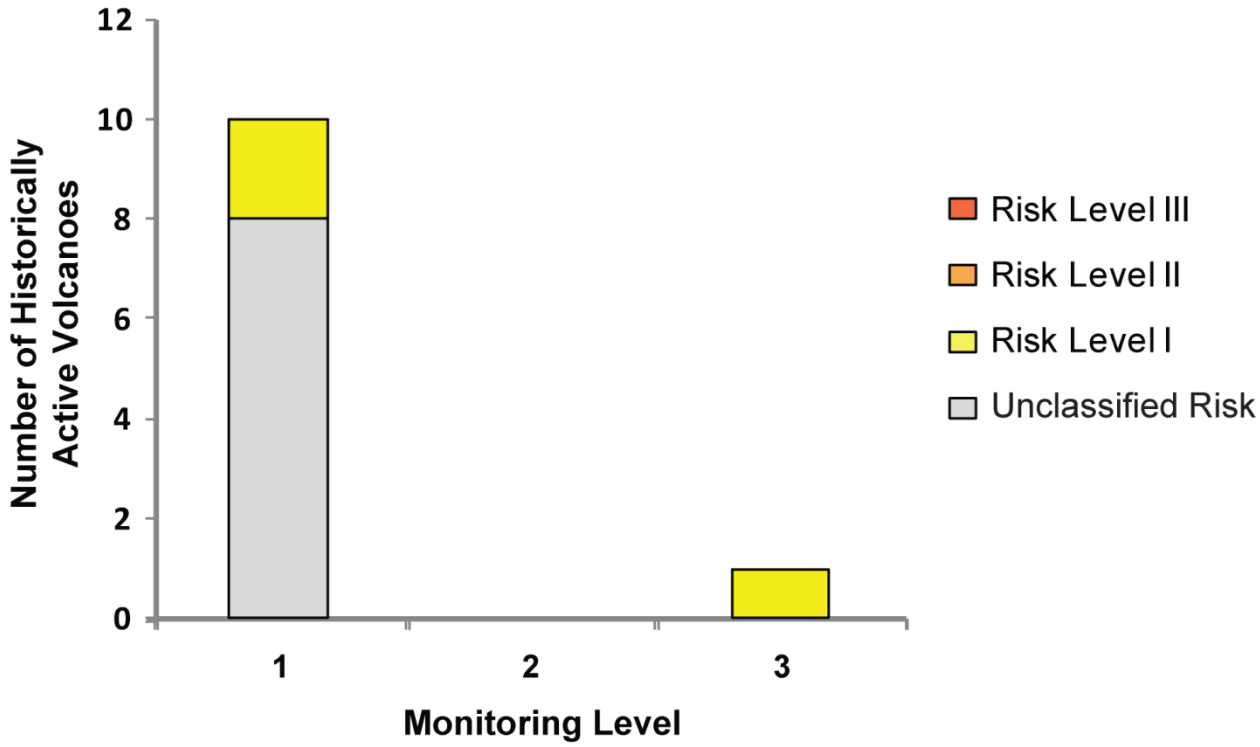

Figure 8.15 The monitoring and risk levels of the historically active volcanoes in the Marianas Islands. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.