Appendix B – Region 5

Country and regional profiles of volcanic hazard and risk:

Melanesia and Australia

S.K. Brown[1], R.S.J. Sparks[1], K. Mee[2], C. Vye-Brown[2], E.Ilyinskaya[2], S.F. Jenkins[1], S.C. Loughlin[2*]

[1]University of Bristol, UK; [2]British Geological Survey, UK, * Full contributor list available in Appendix B Full Download

This download comprises the profiles for Region 5: Melanesia and Australia 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 5: Melanesia and Australia

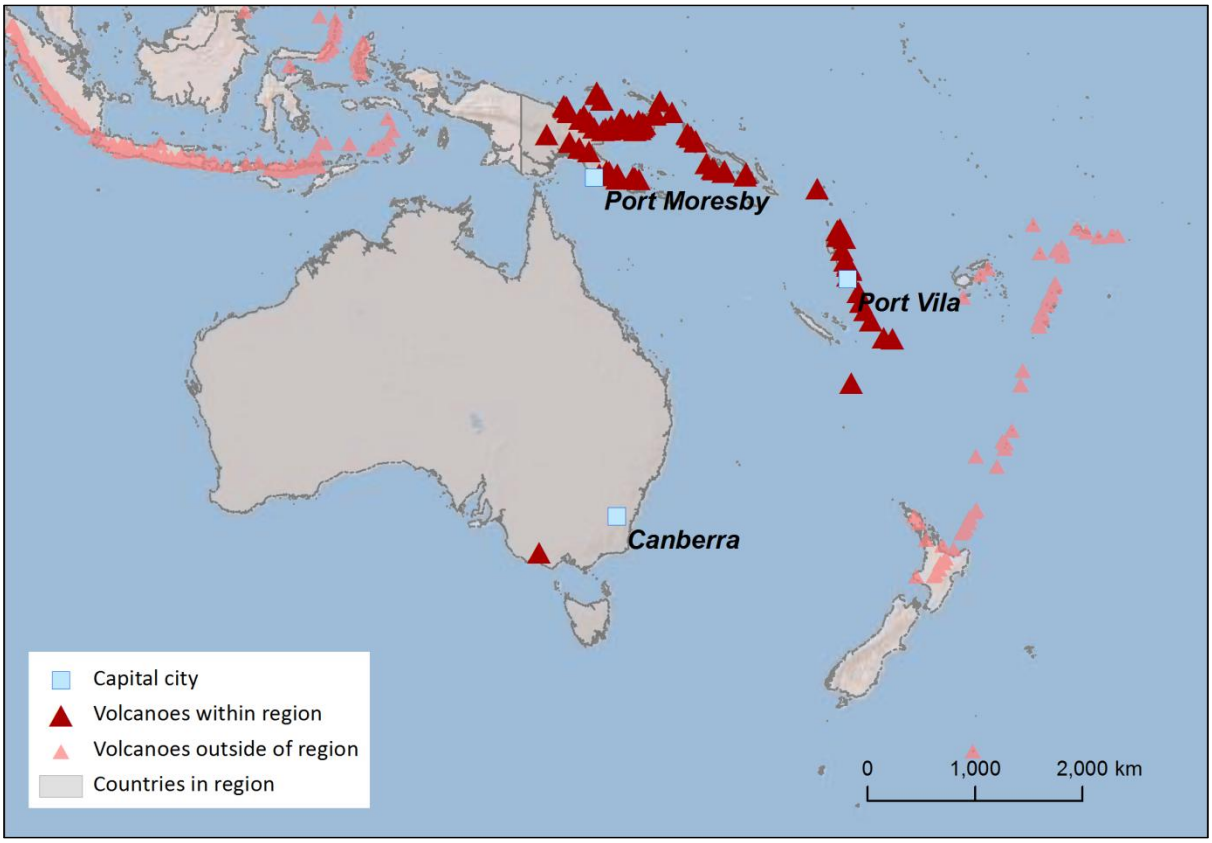

Figure 5.1 The distribution of Holocene volcanoes through the Melanesia and Australia region. The capital cities of the constituent countries are shown.

Description

Region 5, Melanesia and Australia, comprises volcanoes in five countries. Australia, France, Papua New Guinea, the Solomon Islands and Vanuatu. The volcanoes of France in this region are the overseas territories of Matthew and Hunter Islands and Eastern Gemini Seamount, located at the southern end of the Vanuatu chain. The details of these French islands are incorporated into the French Pacific Islands country profile of Region 13. Here, just one Australian volcano is classed as Region 5, but we present two further Australian volcanoes from Region 3 in the Australia profile.

Country	Number of volcanoes
Australia	1 + 2 from Region 3
France (See Region 13)	3
Papua New Guinea	56
Solomon Islands	8
Vanuatu	14

Table 5.1 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.

Volcanism in this region has arisen due to a complex system of plate interactions, with multiple micro-plates located throughout the region. Most volcanoes are due to subduction zone processes, dominantly with the subduction of the Pacific and Solomon Sea Plates. The singular volcano on mainland Australia is due to intra-plate processes. Most volcanoes here are of andesitic or basaltic composition, and a range of volcano types are present throughout the region. About 60% of all volcanoes are stratovolcanoes or types of large cones, with 11% of volcanoes classified as calderas.

Large explosive volcanism is recorded back into the Pleistocene, with seven volcanoes having Pleistocene records of VEI ≥4 eruptions. Despite this, the more recent record is sparse until historical times. 83 volcanoes have had confirmed or suspected Holocene activity, of which 37 have historical activity. Of a total of 449 Holocene eruptions, 400 are dated post-1500 AD, and 86% of events have been recorded through historical observations. The absence of a comprehensive record prior to recent centuries means that full understanding of activity and hazard here is difficult.

Holocene activity has comprised eruptions of VEI 0 to 6, indicating a range of small to very large explosive events. Explosive activity is relatively common with about 8% of eruptions of VEI ≥4, and with moderate to large explosive events occurring about every 13 years. Approximately 12% of historical eruptions have produced pyroclastic flows.

The population through this region is such that most volcanoes are classed with low to moderate PEI values. However, about 260,000 people live within 10 km of one or more Holocene volcano, within the distance where many of the hazardous flows are concentrated. 25 historical eruptions have resulted in fatalities (6% of historical eruptions here), with most deaths attributed to pyroclastic flows and tsunamis. This region ranks third for the number of tsunami-generating eruptions historically.

Dedicated volcano monitoring is in place in Papua New Guinea, Vanuatu and the Solomon Islands, though most frequently using few seismic stations. The only Risk Level III volcano in the region, Rabaul in Papua New Guinea, is monitored by the Rabaul Volcano Observatory, with multiple dedicated ground-based monitoring systems.

Volcano Facts

Number of Holocene volcanoes	83
Number of Pleistocene volcanoes with M≥4 eruptions	7
Number of volcanoes generating pyroclastic flows	24 (69 eruptions)
Number of volcanoes generating lahars	13 (17 eruptions)
Number of volcanoes generating lava flows	20 (110 eruptions)
Number of eruptions with fatalities	28
Number of fatalities attributed to eruptions	10,445
Largest recorded Pleistocene eruption	The M7.4 Kiau Ignimbrite eruption at Long Island at 19,245 BP.

Largest recorded Holocene eruption	The largest recorded Holocene eruption in this region was the 998 BP Dk eruption of Dakataua at M7.4.
Number of Holocene eruptions	449 confirmed Holocene eruptions.
Recorded Holocene VEI range	0 – 6 and unknown
Number of historically active volcanoes	37
Number of historical eruptions	400

Number of volcanoes	Primary volcano type	Dominant rock type
9	Caldera(s)	Andesitic (3), Basaltic (3), Dacitic (2), Rhyolitic (1)
1	Hydrothermal field	Andesitic (1)
48	Large cone(s)	Andesitic (24), Basaltic (20), Dacitic (1), Phonolitic (2), Rhyolitic (1)
1	Lava dome(s)	Andesitic (1)
2	Shield(s)	Basaltic (2)
11	Small cone(s)	Andesitic (6), Basaltic (2), Dacitic (1), Rhyolitic (2)
9	Submarine	Andesitic (2), Dacitic (1), Unknown (6)

Table 5.2 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)	10

Table 5.3 Average recurrence interval (years between eruptions) for small and large eruptions in Melanesia and Australia.

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 10 years.

Eruption Size

Eruptions are recorded through the Melanesia and West Asia region of VEI 0 to 6, representing a range of eruption styles from gentle effusive events to very large explosive eruptions. VEI 2 events dominate the record, with nearly 60% of all Holocene eruptions classed as such. Of the eruptions here, 7.6% are of VEI ≥4.

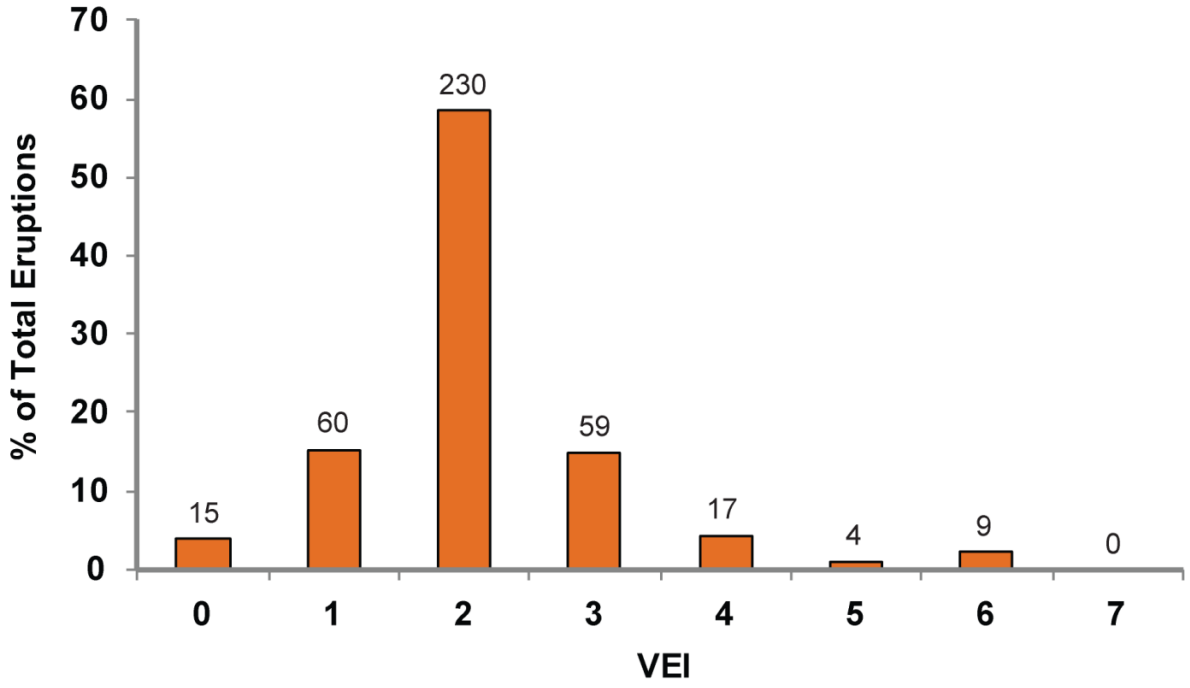

Figure 5.2 Percentage of eruptions in this region recorded at each VEI level; the number of eruptions is also shown. The percentage is of total eruptions with recorded VEI. A further 55 eruptions were recorded with unknown VEI.

Socio-Economic Facts

Total population (2011)	7,187,689
Gross Domestic Product (GDP) per capita (2005 PPP $)	2,363 – 34,548 (Mean 10,889)
Gross National Income (GNI) per capita (2005 PPP $)	2,172 – 34,340 (Mean 10,715)
Human Development Index (HDI) (2012)	0.466 – 0.938 (Low to Very High, Mean 0.64 Medium)

Population Exposure

Number (percentage) of people living within 10 km of a Holocene volcano	257,684 (3.59 %)
Number (percentage) of people living within 30 km of a Holocene volcano	1,252,172 (17.42 %)
Number (percentage) of people living within 100 km of a Holocene volcano	5,869,560 (81.66 %)

CLASSIFIED	**Hazard III**		Long Island; Ulawun; Bagana; Aoba	Manam; Karkar		Rabaul		
	Hazard II		Ambrym; Lopevi	Yasur	Pago			
	Hazard I		Bam; Ritter Island; Kavachi; Tinakula; Gaua; Epi; Kuwae	Langila				
UNCLASSIFIED	**U – HHR**	**Eastern Gemini Seamount; Hunter Island**; **Unnamed (258030)**	**St. Andrew Strait**; **Unnamed (250030)**; Dakataua; **Bamus**; **Victory**; **Waiowa**; Billy Mitchell; **Simbo**; Traitor's Head; **Matthew Island**	**Garbuna Group**; **Lolobau**; **Lamington**; Savo; **Suretamatai**				
	U- HR		**Loloru**	Hargy; **Dawson Strait Group**; Ambitle		Tavui		Newer Volcanics Province
	U-NHHR		Baluan; Blup Blup; **Kadovar**; Boisa; **Unnamed (252001)**; Yomba; **Umboi**; Sakar; Unnamed; Mundua; Bola; **Sulu Range**; Unnamed; Madilogo; Hydrographers Range; Musa River; Iamalele; Lihir; Tore; **Balbi**; Kana Keoki; Coleman Seamount; Unnamed; Motlav; Mere Lava; **Unnamed (255061)**; Aneityum	Garove; Doma Peaks; Crater Mountain; **Yelia**; Managlase Plateau; Sessagara; Goodenough; Takuan Group; North Vate	Garua Harbour; Lolo; Koranga; Gallego			
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 5.4 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 '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.*

Population Exposure Index

Number of Volcanoes	Population Exposure Index
1	7
0	6
2	5
5	4
21	3
51	2
3	1

Table 5.5 The number of volcanoes in Melanesia and Australia classed in each PEI category.

Risk Levels

Number of Volcanoes	Risk Level
1	III
8	II
10	I
18	Unclassified

Table 5.6 The number of volcanoes in the Melanesia and Australia region classified at each Risk Level.

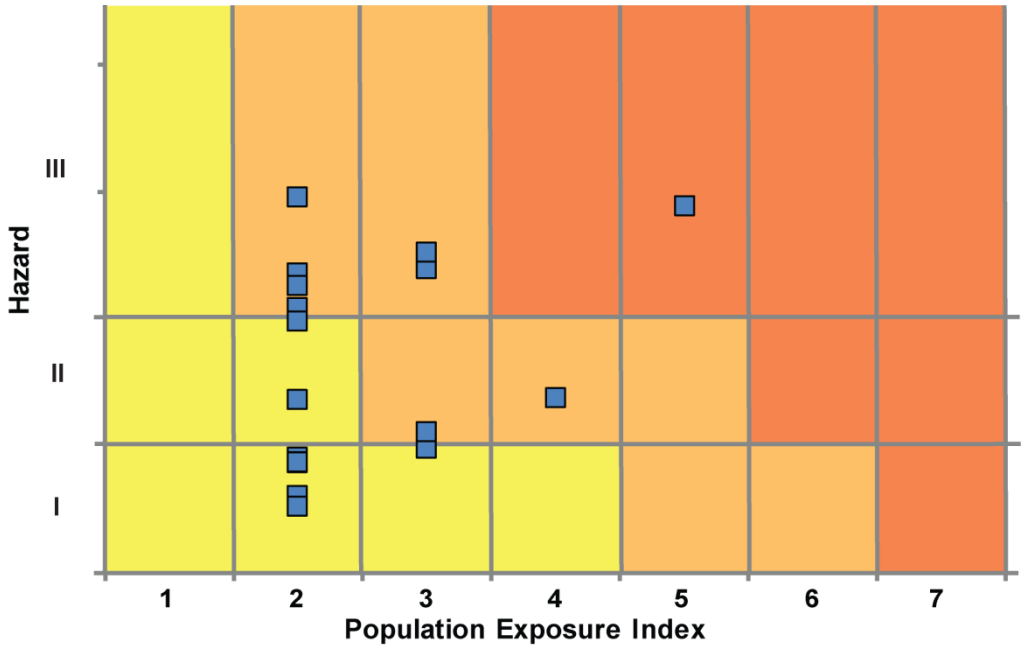

Figure 5.3 Distribution of the classified volcanoes of this region across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

Regional Monitoring Capacity

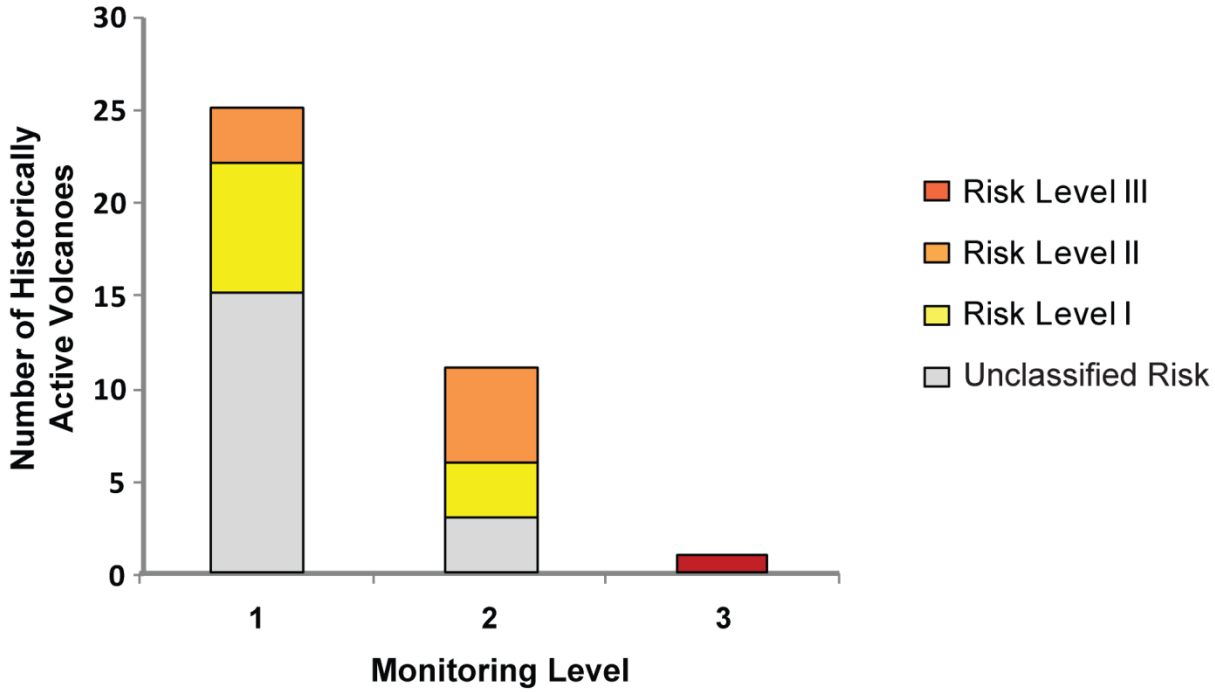

Figure 5.4 The monitoring and risk levels of the historically active Australian volcanoes of the Heard and McDonald Islands. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

Australia

Note that we include here the two Australian volcanoes located in the Indian Ocean, which are included in the Region 3 “Middle East and Indian Ocean” description, as defined in this region by the Global Volcanism Program.

Description

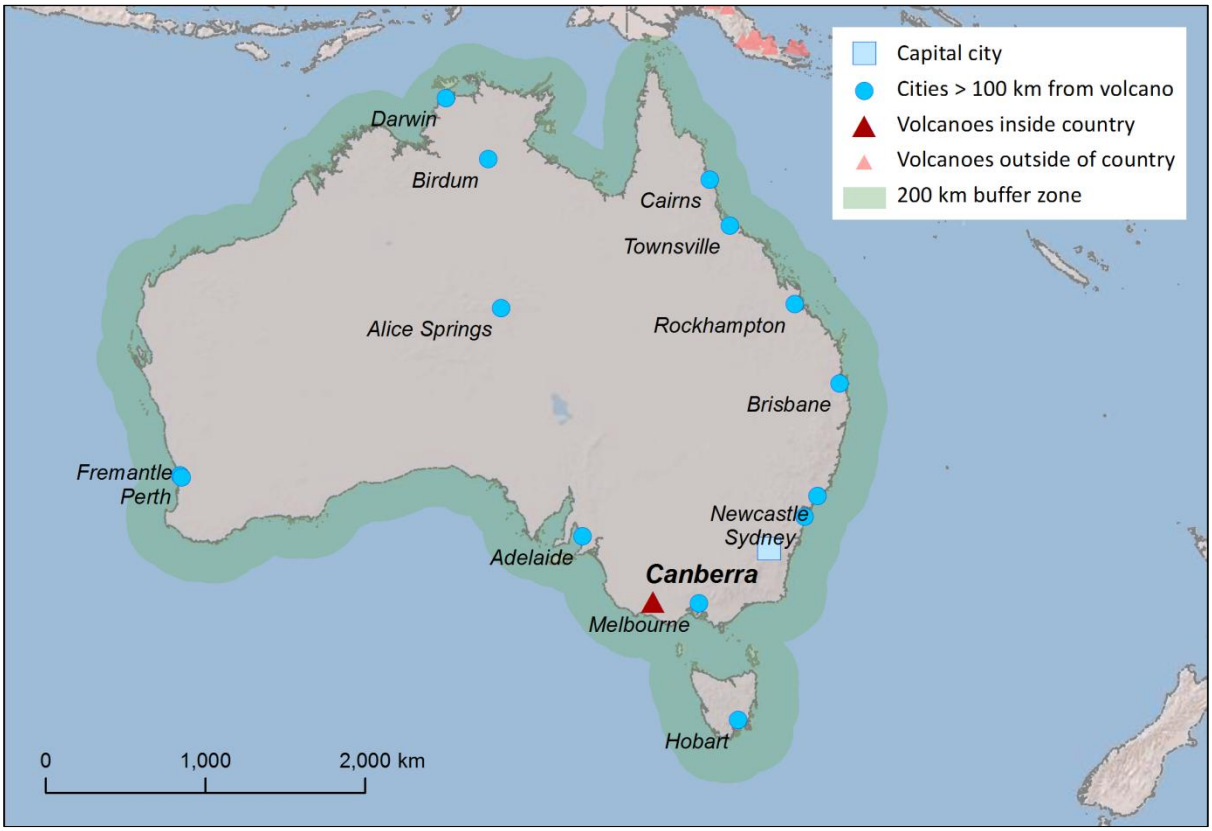

Figure 5.5 Location of Australia’s volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Australia.

Australia has three Holocene volcanoes: Mount Gambier in the Newer Volcanic Province of south-eastern Australia, and the Heard and McDonald Islands volcanoes in the southern Indian Ocean. These volcanoes are related to hot spot volcanism.

All three of Australia’s Holocene volcanoes have Holocene records of lava flows, and two of these volcanoes – those in the Indian Ocean – have records of historical activity, with eruptions as recent as 2012. These volcanoes are basaltic to Phonolitic in composition, with a Holocene record of eruptions of VEI 0 to 2, indicating predominantly effusive to mildly explosive activity.

Less than 1% of the total Australian population lives within 100 km of the Holocene volcanoes, although this represents over 600,000 people living within 10 km of the Newer Volcanics Province. This suggests that even small eruptions could cause extensive damage to property and infrastructure here

There is no dedicated regular ground-based monitoring of Australia's volcanoes. Geoscience Australia (GA) is the national agency for geoscientific information and would be responsible for monitoring efforts. GA have experience monitoring, through a twinning programme with the Rabaul Volcanological Observatory in Papua New Guinea. There are seismometers available for deployment should volcanic unrest be detected which can telemeter data back to GA in real-time and access to satellite data can be arranged. Were an emergency event to occur in the Newer Volcanics Province, GA would provide information and advice to the Crisis Coordination Centre of Emergency Management Australia.

Volcano Facts

Number of Holocene volcanoes	3
Number of Pleistocene volcanoes with M≥4 eruptions	-
Number of volcanoes generating pyroclastic flows	1 (Explosive activity at Mount Gambier about 5,000 years ago)
Number of volcanoes generating lahars	-
Number of volcanoes generating lava flows	3
Number of fatalities caused by volcanic eruptions	-
Tectonic setting	Intra-plate
Largest recorded Pleistocene eruption	-
Largest recorded Holocene eruption	7 eruptions are recorded as VEI 2 from Heard volcano from 1881 to 2000 AD.
Number of Holocene eruptions	19 confirmed eruptions. 3 uncertain eruptions.
Recorded Holocene VEI range	0 – 2 and unknown
Number of historically active volcanoes	2
Number of historical eruptions	15

Number of volcanoes	**Primary volcano type**	**Dominant rock type**
2	Large cone(s)	Basaltic (1), Phonolitic (1)
1	Shield(s)	Basaltic (1)

Table 5.7 The number of volcanoes in Australia, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	23,052,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	34,548
Gross National Income (GNI) per capita (2005 PPP $)	34,340
Human Development Index (HDI) (2012)	0.938 (Very High)

Population Exposure

Capital city	Canberra
Distance from capital city to nearest Holocene volcano	652.2 km
Total population (2011)	21,766,711
Number (percentage) of people living within 10 km of a Holocene volcano	157 (<1%)
Number (percentage) of people living within 30 km of a Holocene volcano	4,416 (<1%)
Number (percentage) of people living within 100 km of a Holocene volcano	119,951 (<1%)

Ten largest cities, as measured by population and their population size:

Sydney	4,394,576
Melbourne	3,730,206
Perth	1,446,704
Adelaide	1,074,159
Brisbane	958,504
Newcastle	497,955
Canberra	327,700
Cairns	154,225
Townsville	138,954
Darwin	93,080

Infrastructure Exposure

Number of airports within 100 km of a volcano	0
Number of ports within 100 km of a volcano	1
Total length of roads within 100 km of a volcano (km)	2,577
Total length of railroads within 100 km of a volcano (km)	267

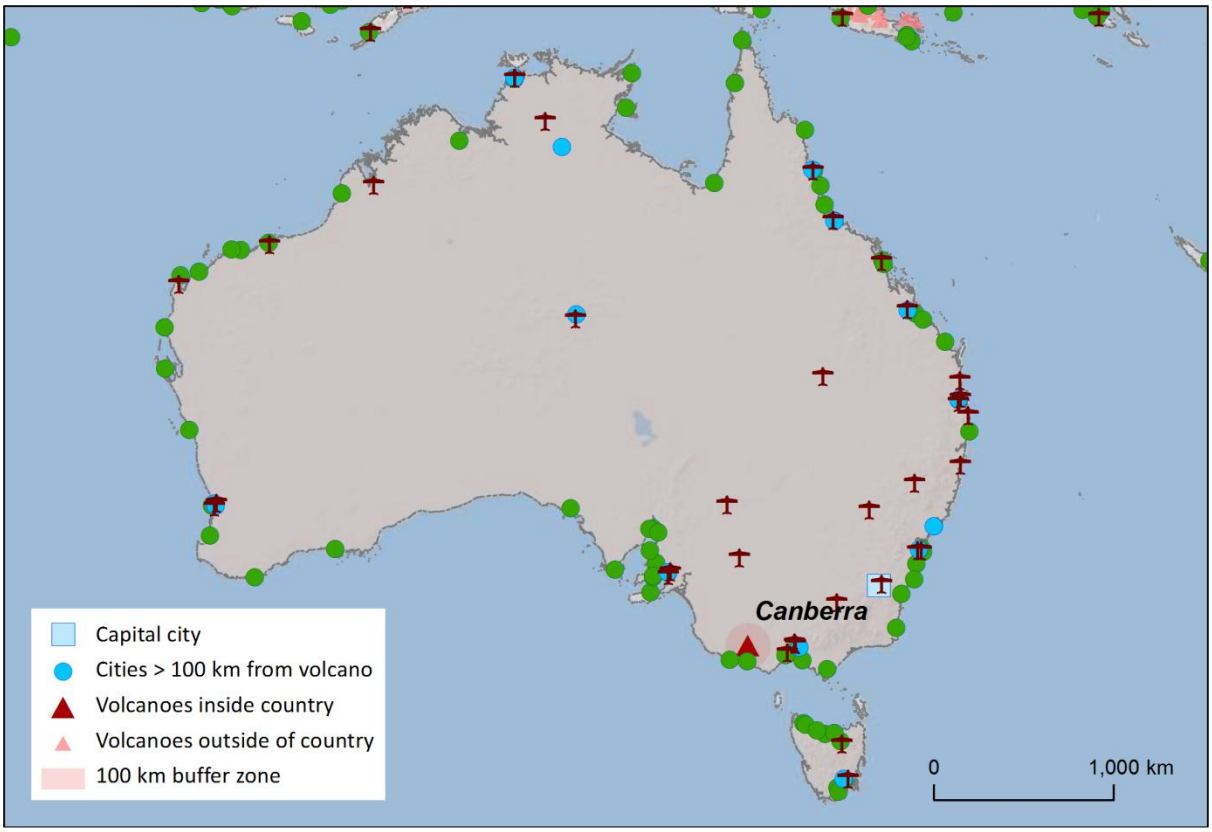

Figure 5.6 The location of Australia's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

The Newer Volcanics Province is situated in Victoria in the south of Australia, about 200 km from the city of Melbourne. Being located near the coast, one port lies within 100 km of this province. Many small communities lie in this radius, exposing their infrastructure, including an extensive road and rail network. The capital, Canberra, is located more than 600 km from this volcanic province.

Hazard, Uncertainty and Exposure Assessments

Although there is a Holocene record of eruptions for all three Australian volcanoes, the size of the eruptions at Newer Volcanics Province is unknown and the hazard cannot therefore be assessed at this volcano without large associated uncertainties. Newer Volcanics Province is therefore unclassified. . A large population is present close to the Newer Volcanics Province, comprising over 600,000 people within 10 km as this field covers a broad area of SE Australia. This makes Newer Volcanics Province a PEI 7 volcano, which in turn categorises it as Risk Level III regardless of the hazard. Heard and McDonald Islands are assigned a Hazard Level of I, based on their eruptive history of events no larger than VEI 2. These volcanoes have no permanent population living within 100 km, and are therefore a PEI of 1 making these Risk Level I volcanoes.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I	Heard; McDonald Islands						
UNCLASSIFIED	**U – HHR**							
	U- HR							Newer Volcanics Province
	U- NHHR							
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 5.8 Identity of Australia'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.*

Volcano	Population Exposure Index	Risk Level
Heard	1	I
McDonald Islands	1	I

Table 5.9 Classified volcanoes of Australia ordered by descending Population Exposure Index (PEI). Risk levels determined through the combination of the Hazard Level and PEI are given. Risk Level I – 2 volcanoes; Risk Level II –0 volcanoes; Risk Level III – 0 volcanoes.

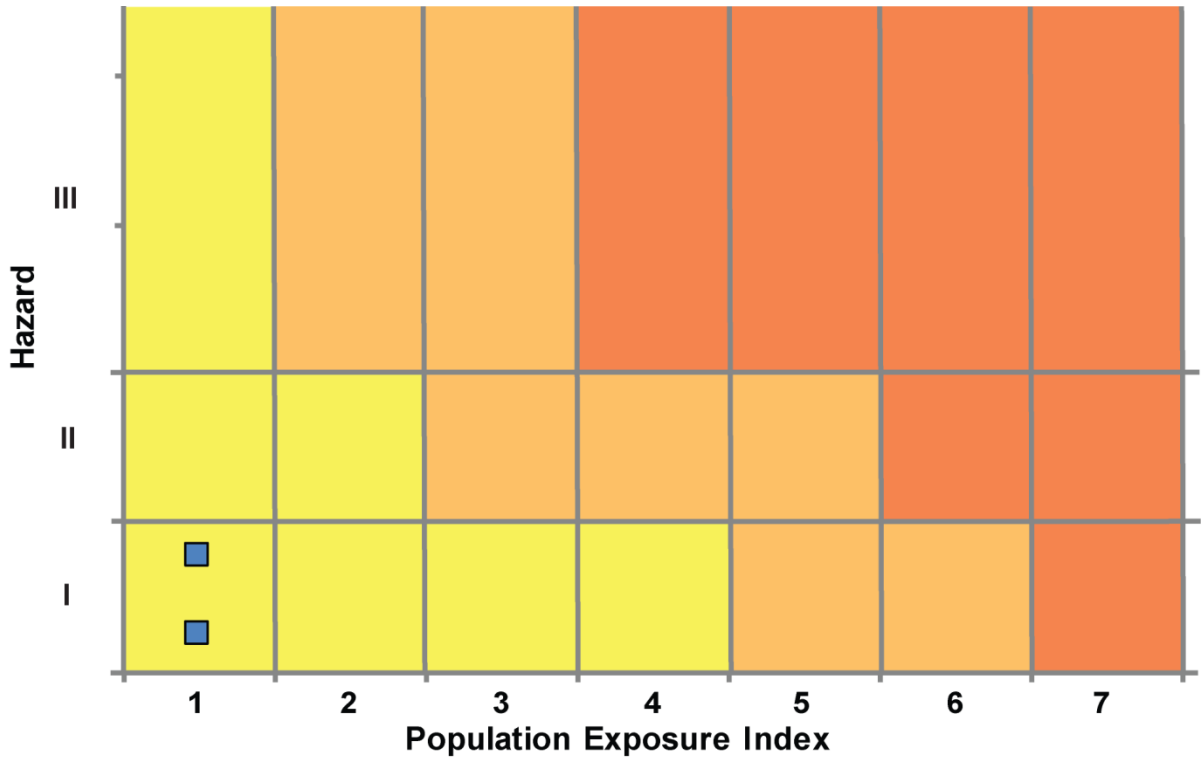

Figure 5.7 Distribution of Australia's classified volcanoes across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

National Capacity for Coping with Volcanic Risk

No volcanoes in mainland Australia have recorded historical eruptions. No regular ground-based monitoring is undertaken at the historically active Heard and McDonald Islands volcanoes in the Indian Ocean.

Papua New Guinea

Description

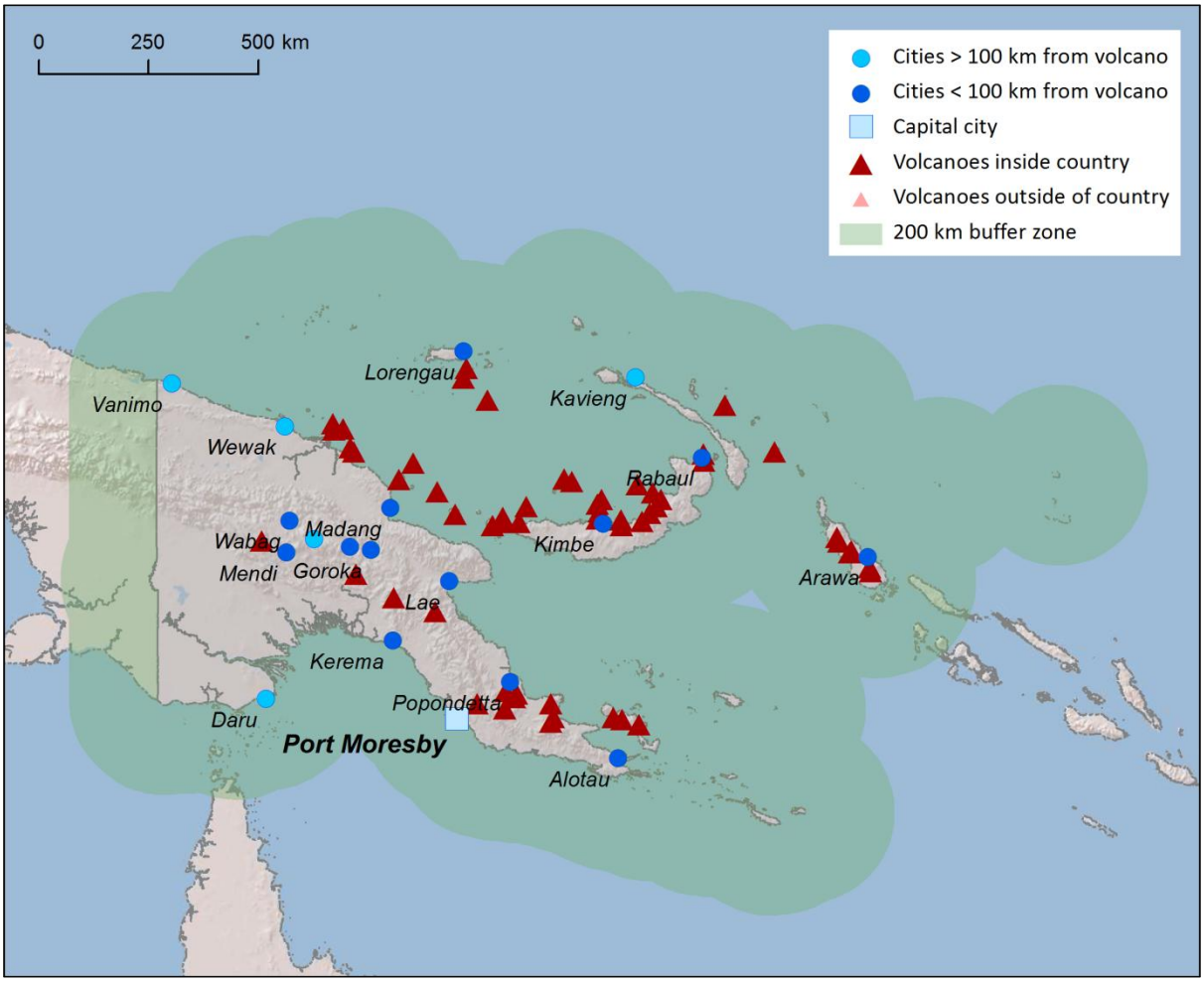

Figure 5.8 Location of Papua New Guinea's volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Papua New Guinea.

Papua New Guinea has 56 Holocene volcanoes distributed throughout the country: from the Doma Peaks near the Indonesian border in the west to Loloru on Bougainville Island in the east, and from St. Andrew Strait in the Admiralty Islands in the north to Dawson Strait Group in the D'Entrecasteaux Islands in the south. Papua New Guinea is located within one of the world's most complex tectonic settings, with seven different plates interacting within the region. The main volcanoes of Papua New Guinea are related to the subduction of the Solomon Sea in the south, and of the Pacific Plate beneath the North Bismarck Plate in the north.

The volcanoes of Papua New Guinea are dominantly stratovolcanoes and large cones and are largely andesitic, with common explosive activity. Large explosive eruptions are recorded into the Pleistocene, with four volcanoes having records of eruptions of VEI/M ≥4. During the Holocene a

range of activity has been recorded, from VEI 0 to 6, with 28 explosive eruptions of VEI ≥4. 17 volcanoes have Holocene records of generating pyroclastic flows and 8 have triggered lahars.

The most active volcano in Papua New Guinea is Bagana, located in the central part of Bougainville Island, with frequent ongoing lava effusion from its summit crater. However, due to the quiet nature of effusive activity and relatively low threat level, it normally goes unnoticed compared to the next two most active volcanoes of Manam and Ulawun. These two volcanoes have had frequent mild to moderate sized historical eruptions and occasional large eruptions with pyroclastic flows.

Much of Papua New Guinea is situated within 100 km of one or more Holocene volcanoes, including many of the largest cities in the country, thus over 80% of the population live within this distance. Port Moresby lies within 55 km of the poorly known Madilogo volcano. Popondetta, home to 28,000, is located 25 km north northeast of Lamington, and Kokopo, which has a population of roughly 21,000, is situated about 15 km southeast from the two most active volcanic cones in Rabaul Caldera; Tavurur and Vulcan.

Of the volcanoes in Papua New Guinea only one, Rabaul, is classed at Risk Level III, with a large proximal population and a high calculated Hazard score. Most volcanoes are classed at Risk Level I, with a relatively low PEI.

The most renowned eruption of a Papua New Guinean volcano is probably that of Lamington in 1951. The peak was not recognised as a volcano before it erupted in January 1951, with a VEI 4 eruption that generated pyroclastic flows and surges that covered all sides of the volcano. The eruption caused 2,492 fatalities and extensive damage. Rabaul is also notable for recent destructive activity. A VEI 4 eruption in 1937 which triggered pyroclastic flows, lahars, and tsunami caused 507 deaths, whilst powerful explosive eruptions in 1994 caused the temporary evacuation of Rabaul City. Five deaths from indirect causes were reported in 1994.

Whilst Lamington and Rabaul are well known for fairly recent, high impact eruptions, in terms of loss of life the largest volcanic disaster in Papua New Guinea was the 1888 eruption of Ritter Island. Located off the western tip of New Britain, this eruption caused massive slope failure that triggered tsunamis that devastated the coastline of mainland Papua New Guinea and claimed approximately 3,000 lives. Along with these three volcanoes, Manam is notable for its persistent activity with forty-three eruptions recorded since 1616. Though activity at Manam is typically mild to moderate, some larger eruptions have impacted populated areas through generation of pyroclastic flows and lavas that have reached low-lying coastal villages. The 2005 VEI 4 eruption at Manam devastated about 70% of the island. 90% of the population was evacuated to the mainland weeks prior to the eruption. Only one death was reported.

The Rabaul Volcanological Observatory is the national institution for monitoring volcanoes in Papua New Guinea. It was established in 1950 to carry out this task and conduct scientific research. It is part of the Department of Mineral Policy and Geohazards Management. The institute is funded by the government of Papua New Guinea and external donors. The institution has 16 staff members, and about 75% have experience of responding to an eruption. Eight volcanoes are regularly monitored and six have dedicated ground-based monitoring networks in place. Mobile equipment and funding resources are available for responding to unrest that may arise at any unmonitored volcano, however these resources are limited.

The Rabaul Volcanological Observatory has been working with certain donor-funded programs with international agencies to conduct risk assessments. It is also involved in risk management and mitigation. As part of its mandate, the observatory provides advice to provincial and national governments on volcano-related issues. A donor-funded programme is currently in place to educate vulnerable communities living around volcanoes about volcanic hazards and the disasters they pose and how to mitigate them. The main aim of the programme is to empower communities to be self-reliant and respond spontaneously during volcanic disasters while they await properly organised relief services from government sources and non-government organisations.

Volcano Facts

Number of Holocene volcanoes	56
Number of Pleistocene volcanoes with M≥4 eruptions	4
Number of volcanoes generating pyroclastic flows	17
Number of volcanoes generating lahars	8
Number of volcanoes generating lava flows	12
Number of fatalities caused by volcanic eruptions	?8,899
Tectonic setting	Subduction zone (55 volcanoes), Rift zone (1 suspected volcano – unnamed - in the Bismarck Sea)
Largest recorded Pleistocene eruption	The M6.7 caldera formation at Lolobau in 12 ka.
Largest recorded Holocene eruption	M7.4 Dk eruption of Dakataua in 998 BP.
Number of Holocene eruptions	246 confirmed eruptions. 38 uncertain eruptions and 11 discredited eruptions.
Recorded Holocene VEI range	0 – 6 and unknown
Number of historically active volcanoes	20
Number of historical eruptions	207

Number of volcanoes	**Primary volcano type**	**Dominant rock type**
7	Caldera(s)	Andesitic (3), Basaltic (1), Dacitic (2), Rhyolitic (1)
1	Hydrothermal field	Andesitic (1)
32	Large cone(s)	Andesitic (18), Basaltic (11), Dacitic (1), Phonolitic (1), Rhyolitic (1)
1	Lava dome(s)	Andesitic (1)
10	Small cone(s)	Andesitic (5), Basaltic (2), Dacitic (1), Rhyolitic (2)
5	Submarine	Unknown (5)

Table 5.10 The number of volcanoes in Papua New Guinea, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	7,187,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	2,363
Gross National Income (GNI) per capita (2005 PPP $)	2,386
Human Development Index (HDI) (2012)	0.466 (Low)

Population Exposure

Capital city	Port Moresby
Distance from capital city to nearest Holocene volcano	52.9 km
Total population (2011)	6,187,591
Number (percentage) of people living within 10 km of a Holocene volcano	226,536 (3.7%)
Number (percentage) of people living within 30 km of a Holocene volcano	1,029,276 (16.6%)
Number (percentage) of people living within 100 km of a Holocene volcano	5,232,230 (84.6%)

Ten largest cities, as measured by population and their population size:

Port Moresby	254,158 (2002 Census)
Lae	76,255
Arawa	40,266
Mount Hagen	33,623
Popondetta	28,198
Madang	27,419
Mendi	26,252
Kokopo	20,262 (PNG Census 2000)
Kimbe	18,847
Goroka	18,503
Wewak	18,230

Infrastructure Exposure

Number of airports within 100 km of a volcano	14
Number of ports within 100 km of a volcano	13

Total length of roads within 100 km of a volcano (km)	643
Total length of railroads within 100 km of a volcano (km)	0

The numerous volcanoes of Papua New Guinea are distributed throughout much of the country, meaning that a large proportion of the country lies within 100 km of a volcano. Twelve of the largest cities in the country lie within these radii, including the capital, Port Moresby, thus much of the critical infrastructure in Papua New Guinea is exposed to volcanic hazards. Being a nation with many islands, multiple ports and airports are exposed.

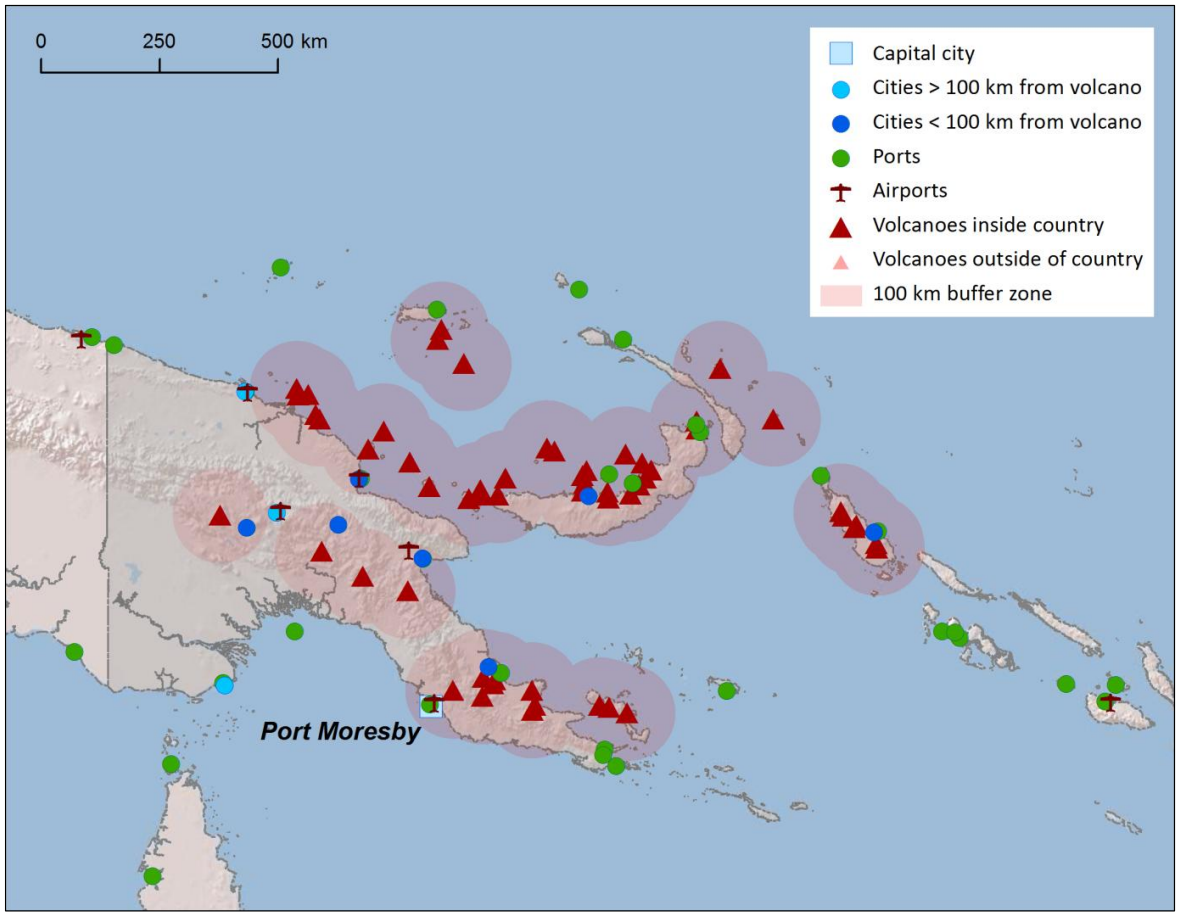

Figure 5.9 The location of Papua New Guinea's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

There are varying levels of data available in the eruption records of Papua New Guinea's volcanoes. Under 20% of the volcanoes here have an appropriate eruptive history for calculation of the hazard. These 10 volcanoes are classified at Hazard Levels I, II and III, with six at Hazard Level III. This could indicate a trend towards particularly hazardous volcanoes in Papua New Guinea, or improved studies and therefore records at volcanoes thought to be hazardous; or a combination of these factors.

Of the unclassified volcanoes 31 have no confirmed eruptions recorded in the Holocene. Five have Holocene records but no historical activity and ten have historical (post-1500 AD) activity. Seven

unclassified volcanoes have erupted since 1900 AD. Eight unclassified volcanoes have records of unrest above background levels since 1900 AD.

The PEI in Papua New Guinea ranges from 2 to 5, low to high. Most classified volcanoes have a low PEI of 2, which in combination with Hazard Levels of I – III, classifies these volcanoes as Risk Levels I and II. Only one volcano, Rabaul, is categorised as Risk Level III in Papua New Guinea, with a high PEI of 5 and a Hazard Level of III.

CLASSIFIED	**Hazard III**		Long Island; Ulawun; Bagana	Manam; Karkar		Rabaul		
	Hazard II				Pago			
	Hazard I		Bam; Ritter Island	Langila				
UNCLASSIFIED	**U – HHR**		**St. Andrew Strait; Unnamed (250030);** Dakataua; **Bamus**; **Victory**; **Waiowa**; Billy Mitchell	**Garbuna Group;** **Lolobau**; **Lamington**				
	U- HR		**Loloru**	Hargy; **Dawson Strait Group**; Ambitle		Tavui		
	U- NHHR		Baluan; Blup Blup; **Kadovar**; Boisa; Unnamed; Yomba; **Umboi**; Sakar; **Unnamed (252001);** Mundua; Bola; **Sulu Range;** Unnamed; Madilogo; Hydrographers Range; Musa River; Iamalele; Lihir; Tore; **Balbi**	Garove; Doma Peaks; Crater Mountain; **Yelia**; Managlase Plateau; Sessagara; Goodenough; Takuan Group	Garua Harbour; Lolo; Koranga			
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 5.11 Identity of Papua New Guinea'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.*

Volcano	Population Exposure Index	Risk Level
Rabaul	5	III
Pago	4	II
Manam	3	II
Karkar	3	II
Langila	3	I
Long Island	2	II
Ulawun	2	II
Bagana	2	II
Bam	2	I
Ritter Island	2	I

Table 5.12 Classified volcanoes of Papua New Guinea 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 – 6 volcanoes; Risk Level III – 1 volcano.

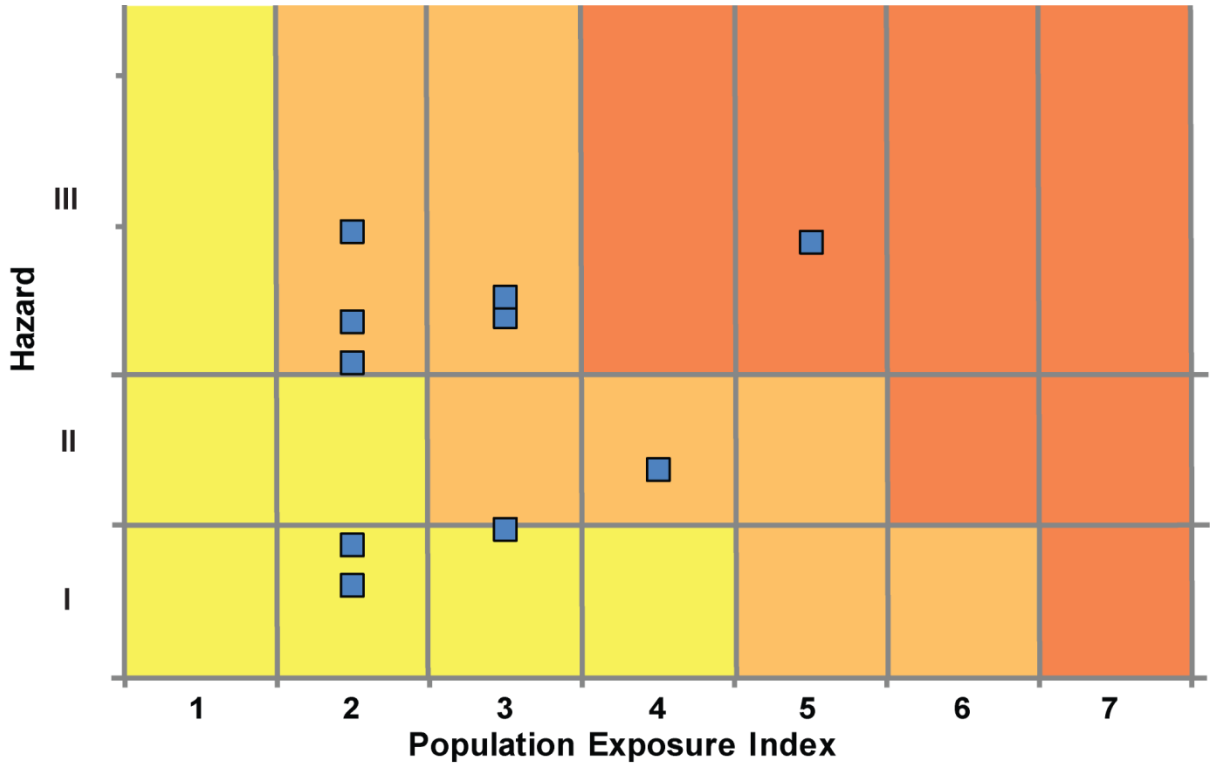

Figure 5.10 Distribution of Papua New Guinea's classified volcanoes across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

National Capacity for Coping with Volcanic Risk

The Rabaul Volcanological Observatory is responsible for the monitoring of the volcanoes in Papua New Guinea, twenty of which have historical records of activity. Eight volcanoes are regularly

monitored and six have dedicated ground-based monitoring systems in place, including five volcanoes with one seismometer and Rabaul volcano with seismic and deformation networks and gas monitoring. Rabaul, as the only Risk Level III volcano in Papua New Guinea, has the greatest level of monitoring. Three Risk Level II volcanoes are not currently monitored through ground-based equipment. The Risk Level II Bagana and Risk Level I Langila have dedicated volcano observers who report in daily and the Rabaul Volcanological Observatory has some resources in place to respond to developing situations.

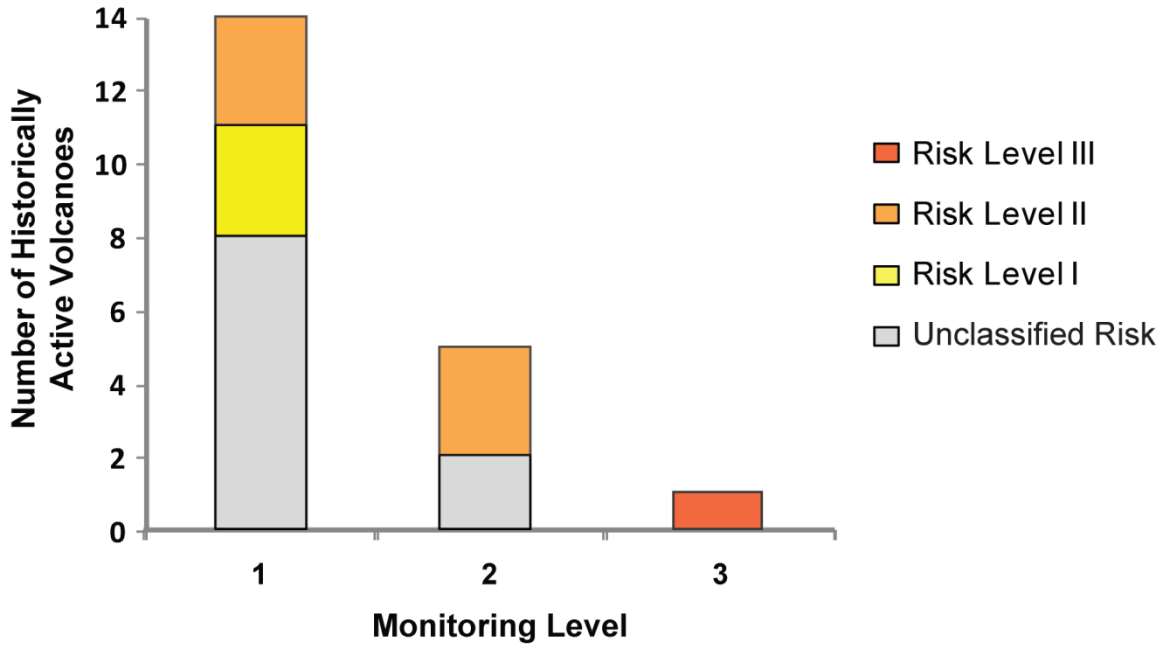

Figure 5.11 The monitoring and risk levels of the historically active volcanoes in Papua New Guinea. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

Solomon Islands

Description

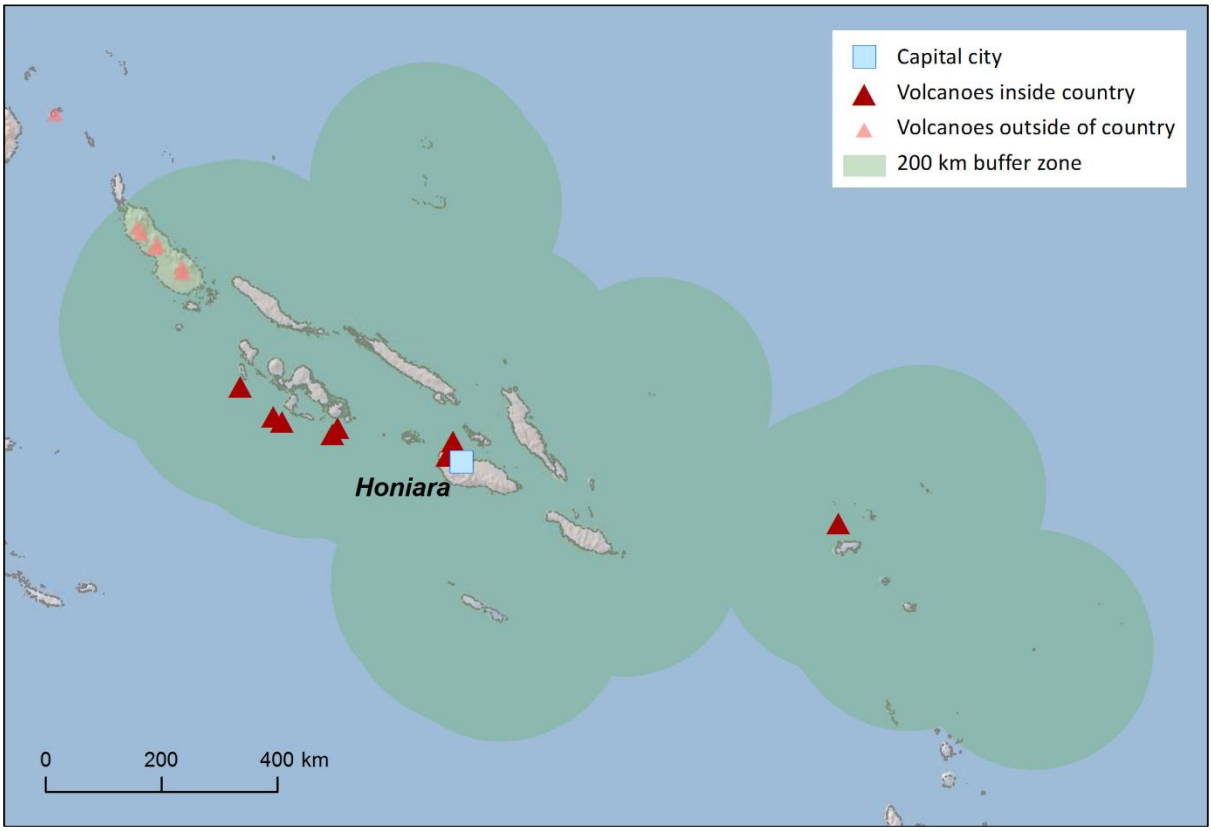

Figure 5.12 Location of Solomon Islands' volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect the Solomon Islands.

Eight Holocene volcanoes are located in the Solomon Islands. These are associated with the subduction of the Solomon Sea Plate beneath the Pacific Plate and a spreading centre at the southeast margin of the Solomon Sea Plate responsible for volcanism at Kavachi. All but Tinakula volcano lie in a north-west to south-east trending line, forming islands to the west of the archipelago. Tinakula is located 600 km to the east of this chain.

The Solomon Islands' volcanoes are made up of four submarine volcanoes, three subaerial stratovolcanoes, and one volcanic field. Two, Savo and Tinakula, have generated pyroclastic flows, and only eruptions of Savo have triggered lahars.

Four volcanoes have 56 historical eruptions of VEI 0 to 3. Six VEI 3 eruptions are recorded at Savo and Tinakula between 1568 and 1965. Tinakula is the most frequently active volcano in the Solomon Islands.

A considerable proportion of the island chain lies within 100 km of one or more Holocene volcanoes and about 50% of the population of the Solomon Islands live within this distance. Most volcanoes have only a small proximal population.

Two eruptions from Savo have had major impacts, namely those in 1568 and 1840; the 1568 eruption generated pyroclastic flows that killed the island's approximately 1,000 inhabitants, whilst ash and ballistics killed many during the 1840 eruption.

Other noteworthy volcanoes in the Solomon Islands are Tinakula and Kavachi. Tinakula is the only other Solomon Islands volcano known to have caused fatalities, when a VEI 3 eruption in 1840 produced pyroclastic flows that swept all sides of the island and killed its inhabitants. Kavachi is one of the most active submarine volcanoes in the entire southwest Pacific, with thirty eruptions recorded since 1939. Kavachi has produced twelve island-forming eruptions in this time, though the volcano's isolated position away from major shipping lanes and airport routes reduces the hazard it poses to people and infrastructure.

Volcano Facts

Number of Holocene volcanoes	8
Number of Pleistocene volcanoes with M≥4 eruptions	-
Number of volcanoes generating pyroclastic flows	2
Number of volcanoes generating lahars	1
Number of volcanoes generating lava flows	2
Number of fatalities caused by volcanic eruptions	?1,200
Tectonic setting	Subduction zone
Largest recorded Pleistocene eruption	-
Largest recorded Holocene eruption	6 eruptions of VEI 3 are recorded at Savo and Tinakula between the years of 1568 and 1965 AD.
Number of Holocene eruptions	57 confirmed eruptions. 5 uncertain eruptions.
Recorded Holocene VEI range	0 – 3 and unknown
Number of historically active volcanoes	4
Number of historical eruptions	56

Number of volcanoes	Primary volcano type	Dominant rock type
3	Large cone(s)	Andesitic (3)
1	Small cone(s)	Andesitic (1)
4	Submarine	Andesitic (2), Dacitic (1), Unknown (1)

Table 5.13 The number of volcanoes in the Solomon Islands, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	551,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	2,581
Gross National Income (GNI) per capita (2005 PPP $)	2,172
Human Development Index (HDI) (2012)	0.530 (Low)

Population Exposure

Capital city	Honiara
Distance from capital city to nearest Holocene volcano	21.7 km
Total population (2011)	571,890
Number (percentage) of people living within 10 km of a Holocene volcano	4,545 (<1%)
Number (percentage) of people living within 30 km of a Holocene volcano	98,612 (17.2%)
Number (percentage) of people living within 100 km of a Holocene volcano	286,531 (50.1%)

Largest cities, as measured by population and their population size:

Honiara	56,298

Infrastructure Exposure

Number of airports within 100 km of a volcano	1
Number of ports within 100 km of a volcano	6
Total length of roads within 100 km of a volcano (km)	0
Total length of railroads within 100 km of a volcano (km)	0

The volcanoes of the Solomon Islands are mainly located to the west of the largest islands. A considerable proportion of the island chain lies within 100 km of a Holocene volcano. Many ports are located in these radii, and an airport in the capital, Honiara, which lies at less than 25 km from Gallego volcano, and less than 40 km from the historically active Savo volcano. This places much of the country's critical infrastructure within 100 km of Holocene volcanoes. The northern tip of northernmost Choiseul Island lies within 100 km of volcanoes on Bougainville Island, an autonomous region of Papua New Guinea.

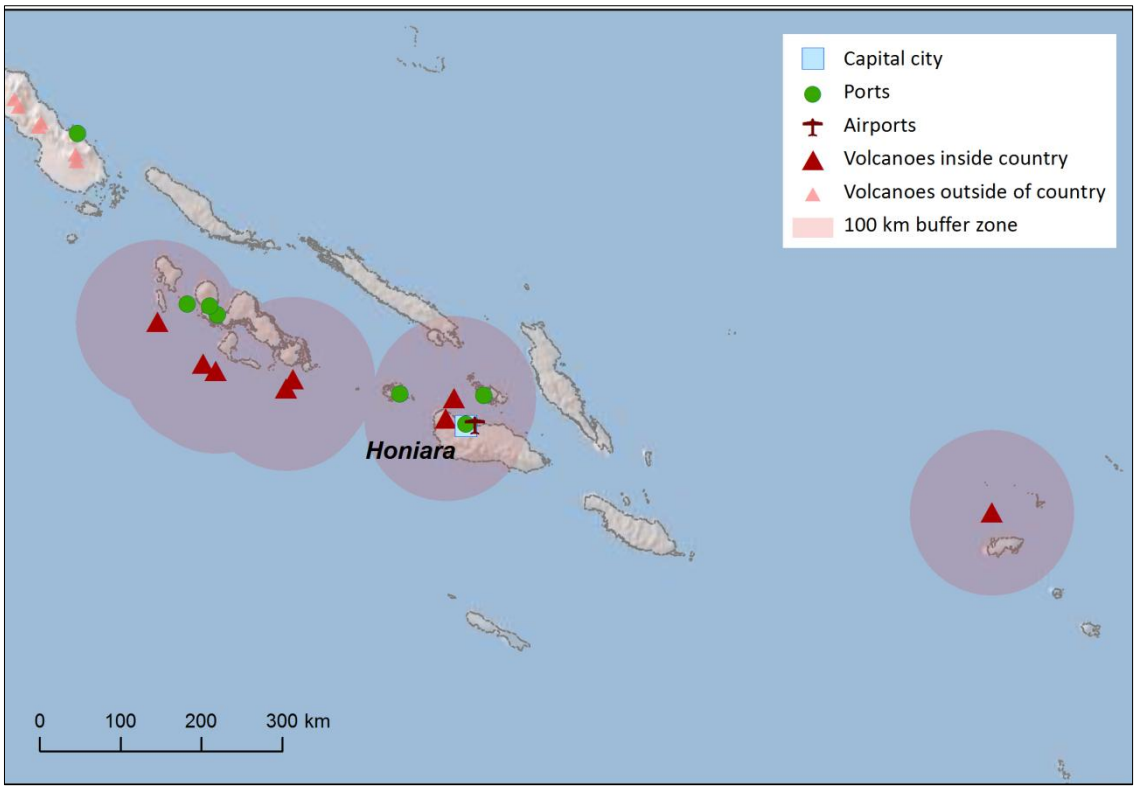

Figure 5.13 The location of the Solomon Islands' volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Hazard, Uncertainty and Exposure Assessments

Six of the eight volcanoes of the Solomon Islands lack sufficiently extensive eruptive histories for calculation of the hazard without large associated uncertainties. These volcanoes are therefore unclassified. Of these, just two have records of eruptions; Simbo and Savo both have historical eruptions.

Kavachi and Tinakula volcanoes have 53 confirmed Holocene eruptions, most commonly of VEI 1-2. These volcanoes are classified at Hazard Level I.

Most Solomon Island volcanoes are PEI 2, and indeed both classified volcanoes are categorised as such, classifying these as Risk Level I. The highest PEI in the Solomon Islands is PEI 4 at Gallego volcano which lies within 100 km of the capital, Honiara.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I		Kavachi; Tinakula					
UNCLASSIFIED	**U – HHR**		**Simbo**	Savo				
	U- HR							
	U-NHHR		Kana Keoki; Coleman Seamount; **Unnamed (255061)**		Gallego			
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 5.14 Identity of the volcanoes in the Solomon Islands 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
Kavachi	2	I
Tinakula	2	I

Table 5.15 Classified volcanoes of the Solomon 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 – 2 volcanoes; Risk Level II – 0 volcanoes; Risk Level III – 0 volcanoes.

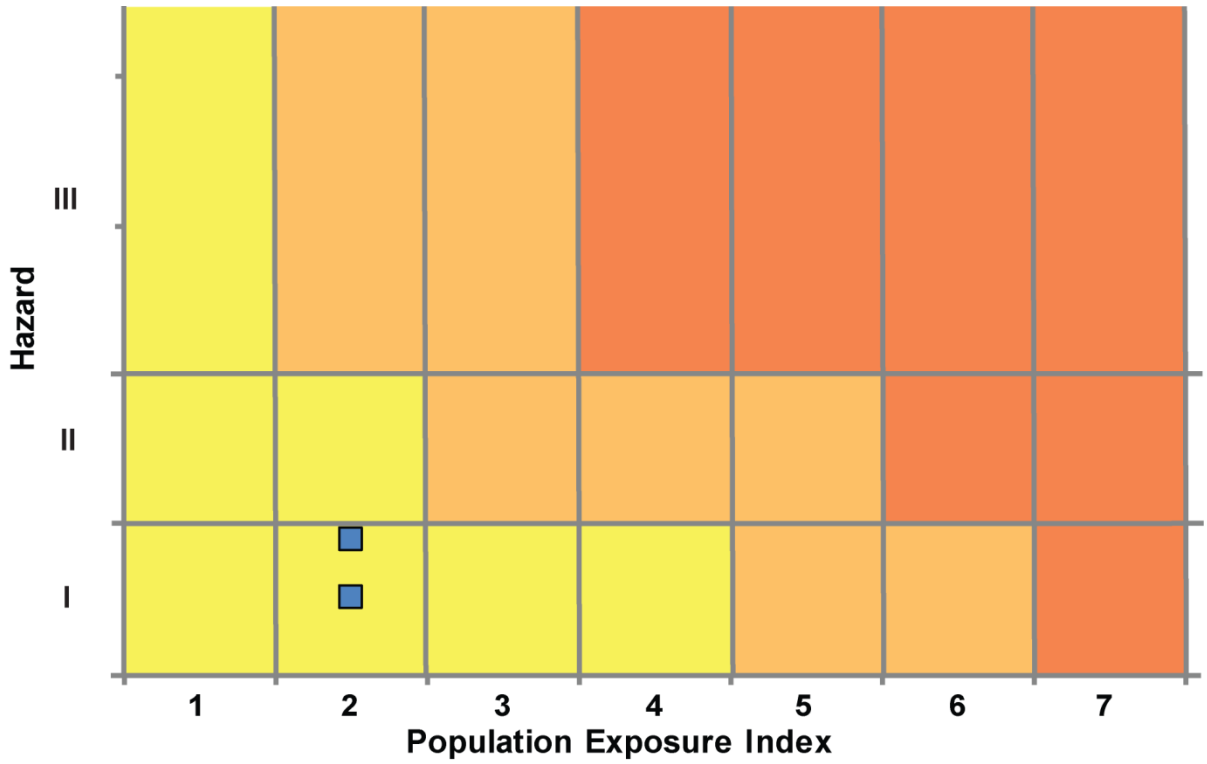

Figure 5.14 Distribution of the Solomon Islands' classified volcanoes across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

National Capacity for Coping with Volcanic Risk

Four volcanoes have records of historical eruptions: Kavachi, Tinakula, Simbo and Savo. Of these, the latter two are unclassified for hazard and risk. The World Organisation of Volcano Observatories (WOVO) indicates that of the volcanoes in the Solomon Islands, only one volcano, Savo, has a dedicated monitoring system in place, comprising an irregularly monitored 3-component seismometer. No other information was available at the time of the writing of this report to suggest further monitoring takes place in the Solomon Islands.

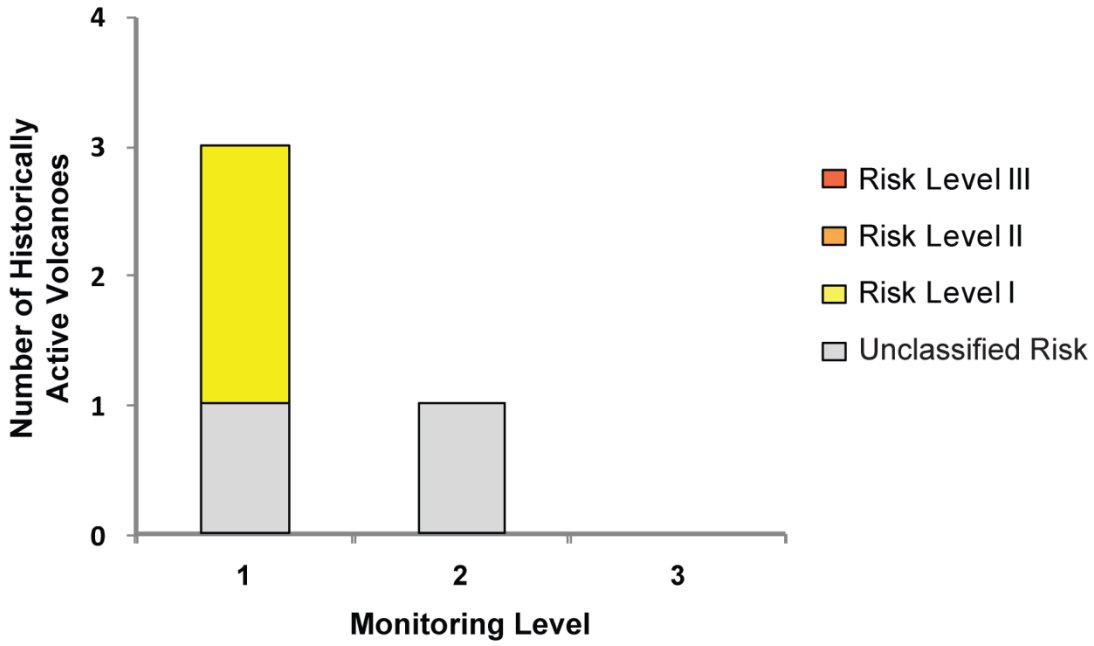

Figure 5.15 The monitoring and risk levels of the historically active volcanoes in the Solomon Islands. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

Vanuatu

Description

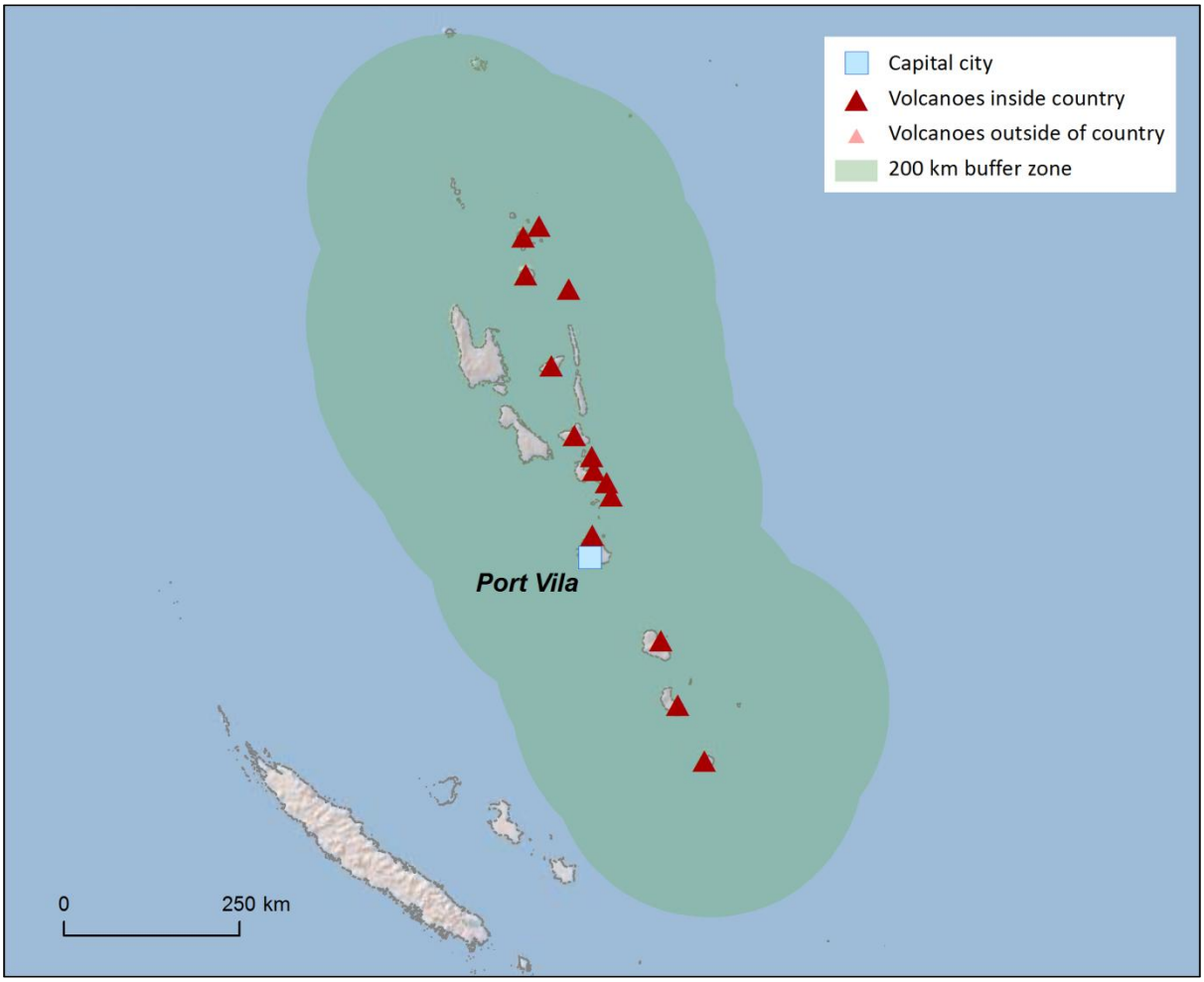

Figure 5.16 Location of Vanuatu's volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect Vanuatu.

Fourteen Holocene volcanoes are located throughout Vanuatu. These lie in a north-south trending line between Tinakula volcano of the Solomon Islands in the north, and the French Eastern Gemini Seamount in the south. These volcanoes result from the subduction of the Australian Plate beneath the Pacific Plate.

The volcanoes of Vanuatu are predominantly basaltic in composition, though most are stratovolcanoes or another edifice type usually associated with explosive activity. Pyroclastic flows are recorded at five volcanoes, including the only shield volcano in Vanuatu, Aoba. Lahars have been generated at three volcanoes. Eruptions of VEI 0 – 6 are recorded during the Holocene, indicating a range of activity styles. Nine volcanoes have had historical activity, producing 128 eruptions since 1500 AD. The record prior to this is sparse, however there is a record of large explosive eruptions at two volcanoes during the Pleistocene, including the M6.9 eruption of the Efaté Pumice formation at North Vate, at 1 Ma.

The most frequently active volcano in Vanuatu is the basaltic caldera, Ambrym, which has had 53 historical eruptions.

An eruption of Aoba in 1870 triggered a lahar that destroyed villages on the southeast flank and killed over 100 people, whilst a flank eruption in 1670 destroyed populated areas near the western coast. Numerous lahar deposits can be seen on the coasts. The Vanuatu Geohazards Observatory suggests that Aoba can be considered the most dangerous volcano in Vanuatu, due to the presence of a large lake in the main crater.

With the exception of the almost persistently active Yasur volcano, Gaua is the most recently active of Vanuatu's volcanoes. An eruption commencing on 27th September 2009 led to explosions and high dense ash plumes on 18th November 2009, with the evacuation of over 300 people following on 26th November 2009. Activity carried on into 2010, and increased in April 2010; plans were made to evacuate a further 3,000 people. Seismic tremors, as well as ash and gas emissions, continued throughout the first 8 months of 2010. The Vanuatu Geohazards Observatory reported on 21st December 2010 that activity from Gaua had been low since September and activity ceased in October 2010.

The eruptive history is sufficiently detailed to determine the hazard with minimal uncertainties at about half of Vanuatu's volcanoes. Aoba is classed with the highest hazard levels in Vanuatu. The volcanoes are distributed through the island chain and as such, the whole population lives within 100 km of one or more Holocene volcano and almost all infrastructure is exposed. Despite this overall total exposure, small to moderate sized populations are located close to individual volcanoes.

The Vanuatu Geohazards Observatory operates a national seismic network and an additional volcano monitoring network. Permanent seismic monitoring is undertaken at Yasur, Ambrym, Aoba and Gaua. The Vanuatu Geohazards Observatory also run a website accessible to all, where alert levels for the volcanoes are provided. Alert levels range from 0 to 4 with increasing activity, and include "Level ?" where there is insufficient monitoring data to make an assessment. This alert level system is linked with a hazards map which indicates danger areas. The Observatory also has plans in place for evacuations dependent on the activity observed.

See also:

Vanuatu Geohazards Observatory, www.geohazards.gov.vu/index.php/home

Volcano Facts

Number of Holocene volcanoes	14
Number of Pleistocene volcanoes with M≥4 eruptions	2
Number of volcanoes generating pyroclastic flows	5
Number of volcanoes generating lahars	3
Number of volcanoes generating lava flows	3

Number of fatalities caused by volcanic eruptions	?>346
Tectonic setting	Subduction zone
Largest recorded Pleistocene eruption	The M6.9 eruption of the Efaté Pumice formation at North Vate, at 1 Ma.
Largest recorded Holocene eruption	Two M6.8 eruptions are recorded here, the 1760 BP eruption of Ambrym and 520 BP eruption of Kuwae.
Number of Holocene eruptions	133 confirmed eruptions. 18 uncertain eruptions.
Recorded Holocene VEI range	0 – 6 and unknown
Number of historically active volcanoes	9
Number of historical eruptions	128

Number of volcanoes	Primary volcano type	Dominant rock type
2	Caldera(s)	Basaltic (2)
11	Large cone(s)	Andesitic (3), Basaltic (8)
1	Shield(s)	Basaltic (1)

Table 5.16 The number of volcanoes in Vanuatu, their volcano type classification and dominant rock type according to VOTW4.0.

Socio-Economic Facts

Total population (2012)	248,000
Gross Domestic Product (GDP) per capita (2005 PPP $)	4,062
Gross National Income (GNI) per capita (2005 PPP $)	3,960
Human Development Index (HDI) (2012)	0.626 (Medium)

Population Exposure

Capital city	Port Vila
Distance from capital city to nearest Holocene volcano	30.2 km
Total population (2011)	224,564
Number (percentage) of people living within 10 km of a Holocene volcano	26,446 (11.8%)

Number (percentage) of people living within 30 km of a Holocene volcano	119,868 (53.4%)
Number (percentage) of people living within 100 km of a Holocene volcano	230,848 (>100%)

Largest cities, as measured by population and their population size:

Port Vila	35,901

Infrastructure Exposure

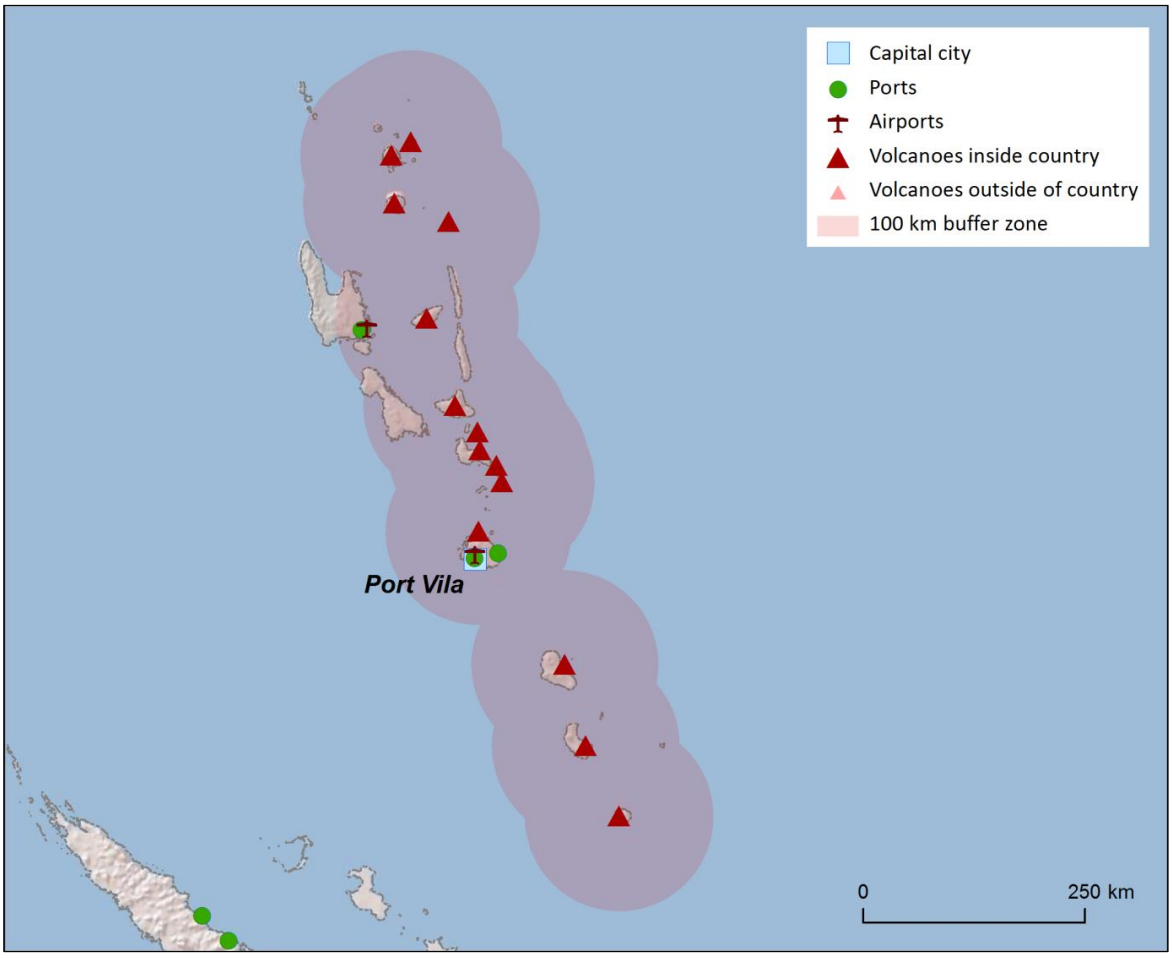

Figure 5.17 The location of Vanuatu's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Number of airports within 100 km of a volcano	2
Number of ports within 100 km of a volcano	3
Total length of roads within 100 km of a volcano (km)	0
Total length of railroads within 100 km of a volcano (km)	0

The volcanoes of Vanuatu are located throughout the island chain, with almost the entire country lying within 100 km of Holocene volcanoes. A number of ports and airports are exposed, and much of the critical infrastructure of the country is located in these 100 km radii. The capital, Port Vila, lies just over 30 km from the nearest Holocene volcano, North Vate.

Hazard, Uncertainty and Exposure Assessments

Half of the volcanoes of Vanuatu have detailed eruptive histories allowing the calculation of hazard. These seven volcanoes are classified at Hazard Levels I, II and III. The only Hazard Level III volcano is Aoba, with a history of pyroclastic flow producing eruptions.

Of the seven unclassified volcanoes, only two have confirmed Holocene eruptions: Traitor's Head and Suretamatai. These volcanoes have erupted historically, as recently as 1965.

The PEI in Vanuatu ranges between 2 and 3 indicative of small to moderate populations. This, in combination with the hazard levels classifies the volcanoes here at Risk Levels I – II.

CLASSIFIED	**Hazard III**		Aoba					
	Hazard II		Ambrym; Lopevi	Yasur				
	Hazard I		Gaua; Epi; Kuwae					
UNCLASSIFIED	**U – HHR**		Traitor's Head	**Suretamatai**				
	U- HR							
	U-NHHR		Motlav; Mere Lava; Unnamed; Aneityum	North Vate				
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 5.17 Identity of Vanuatu'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.*

Volcano	Population Exposure Index	Risk Level
Yasur	3	II
Aoba	2	II
Lopevi	2	I
Ambrym	2	I
Epi	2	I
Gaua	2	I
Kuwae	2	I

Table 5.18 Classified volcanoes of Vanuatu ordered by descending Population Exposure Index (PEI). Risk levels determined through the combination of the Hazard Level and PEI are given. Risk Level I – 5 volcanoes; Risk Level II – 2 volcanoes; Risk Level III – 0 volcanoes.

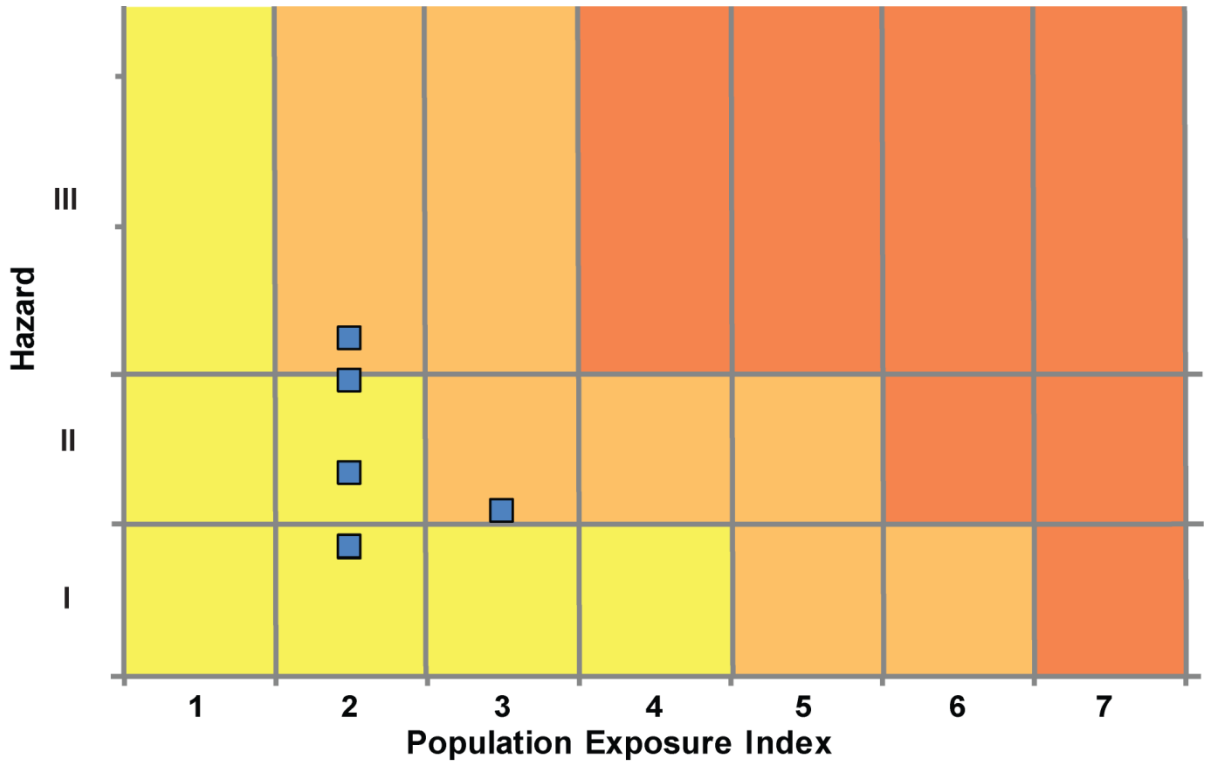

Figure 5.18 Distribution of Vanuatu's classified volcanoes across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

National Capacity for Coping with Volcanic Risk

Volcanism in Vanuatu is monitored by the Vanuatu Geohazards Observatory. A national seismic network (the Vanuatu Seismic Network) is distributed across the islands of the country measuring activity in real-time or near real-time. A further volcano monitoring network is in place including: permanent seismic monitoring at the Risk Level II volcanoes Yasur and Aoba, and Risk Level I Ambrym and Gaua volcanoes, with non-continuous monitoring used at Lopevi. The Risk Level I volcanoes Epi and Kuwae and the unclassified Suretamatai and Traitor's Head volcanoes do not currently have a dedicated monitoring network in place.

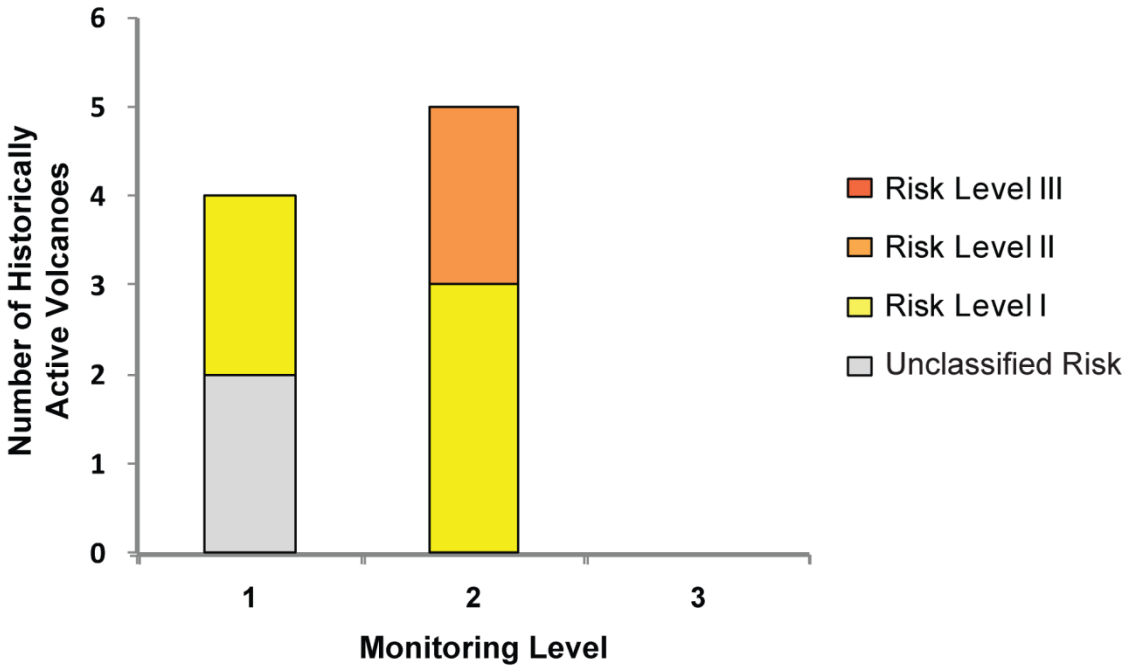

Figure 5.19 The monitoring and risk levels of the historically active volcanoes in Vanuatu. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.