15 Jan 2022
Hunga Tonga Hunga Ha'apai eruption
and
tsunami, Tonga

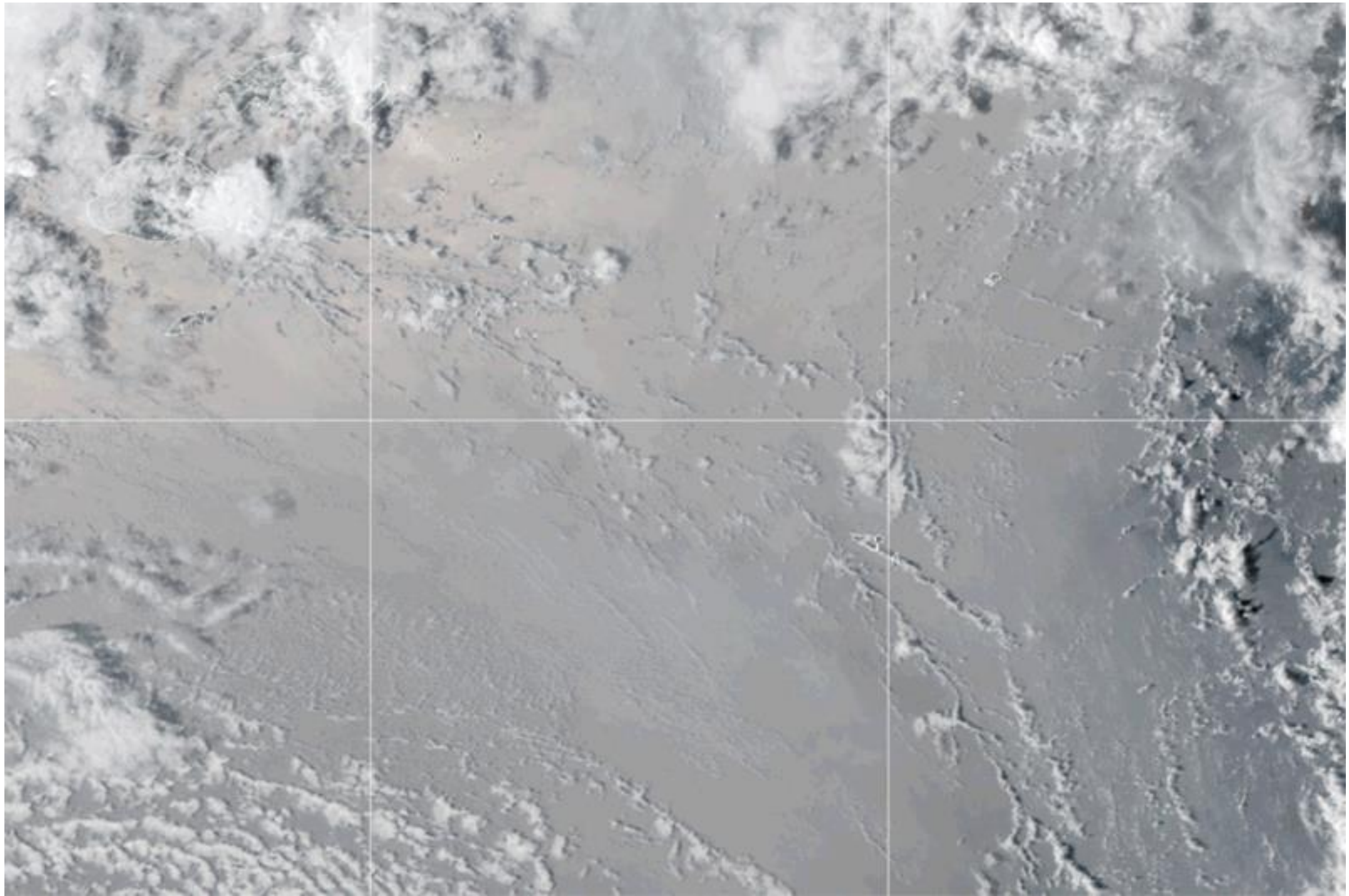
Graham Leonard, Carol Stewart and Tom Wilson

UC UNIVERSITY OF CANTERBURY

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

GNS SCIENCE
TE PŪ AO




2 January 2022
15 January 2022
500 m
Perimeter on 2 January 2022
Copernicus
Europe's eyes on Earth

NZ response: partnerships

In country

- Tonga Geological Service – key lead
- Tonga Meteorological Services – key tsunami lead, also with PTWS
- Via MFAT, Pacific WASH (FIJI) and ESR: Tonga HN-WASH Cluster - Health, Nutrition, Water, Sanitation, Hygiene (with Emergency Management)

Supporting external agencies

- MFAT, NZDF, NEMA, ESR, MOH, Pacific WASH, USGS, USAid, VDAP – Carol and Shane's networks.
- MetService VAAC
- Wide range of agricultural agencies. FAO – Agriculture, Plant and Food, MPI, Manaaki Whenua? Carol and Shane's networks and contacts.
- IVHHN – Key rapid network via Carol.
- Pacific Regional Food Security Cluster

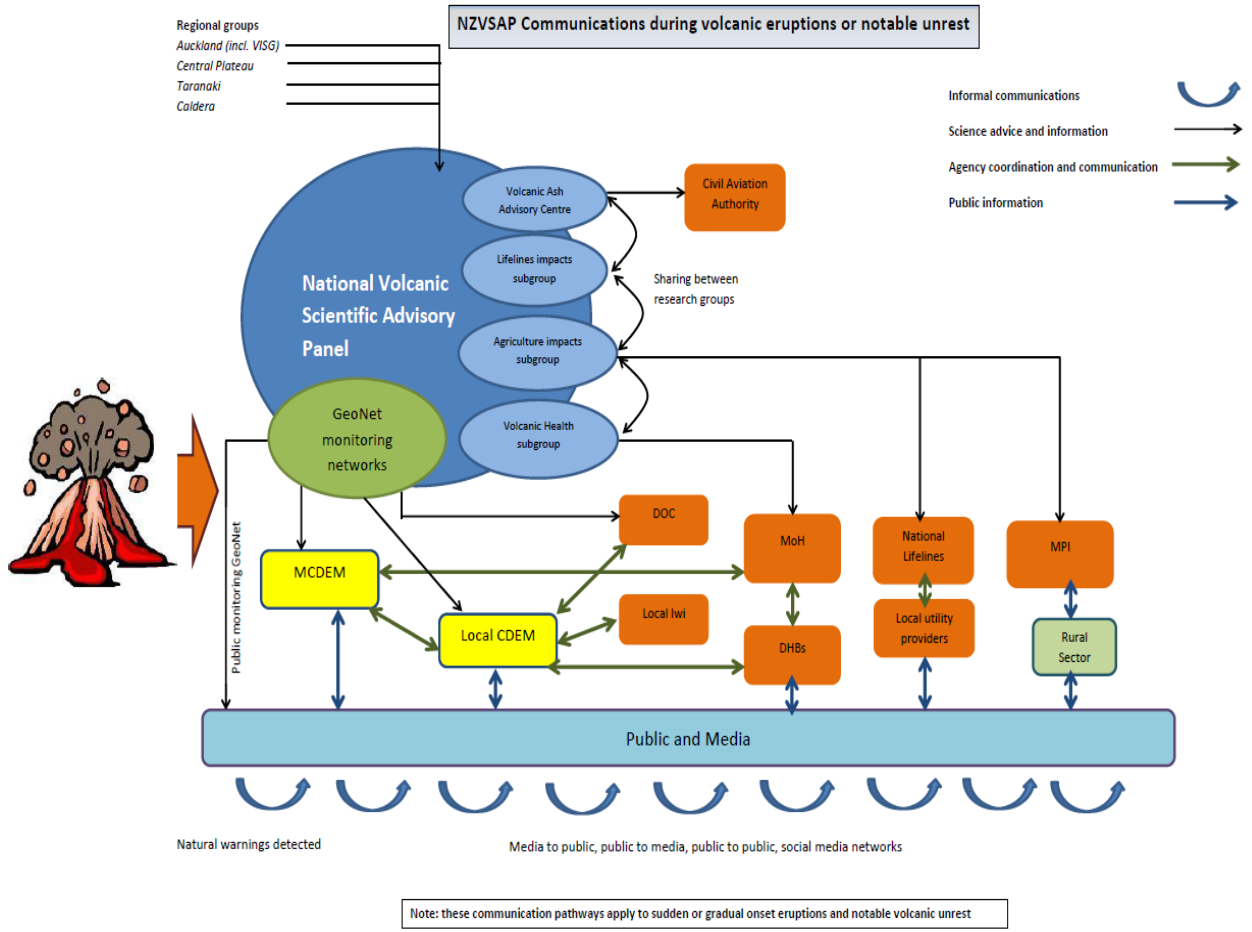
NZVSAP

- GNS, VUW, Massey, Canterbury, Otago, Auckland, NIWA, ESR & MOH (health), MetService. +USGS/international key individuals (BOM, UCSB, InSAR, Satellite)

TSURGE, and Risk/loss community

NZ Volcanic Science Advisory Panel

- Consistent messaging
- Provision of extra expertise to monitoring, volcanic hazard assessment, and impact assessment
- Wider scientific advice to stakeholders
- Coordination of science activities (e.g. sample analysis)
- Lacked clear framework to trigger to assist Pacific nation(s). MFAT is lead agency, GNS coordinated using CIMS-based response.
- Lacked Pasifika representation
- Benefit from recent Pacific eruption experience



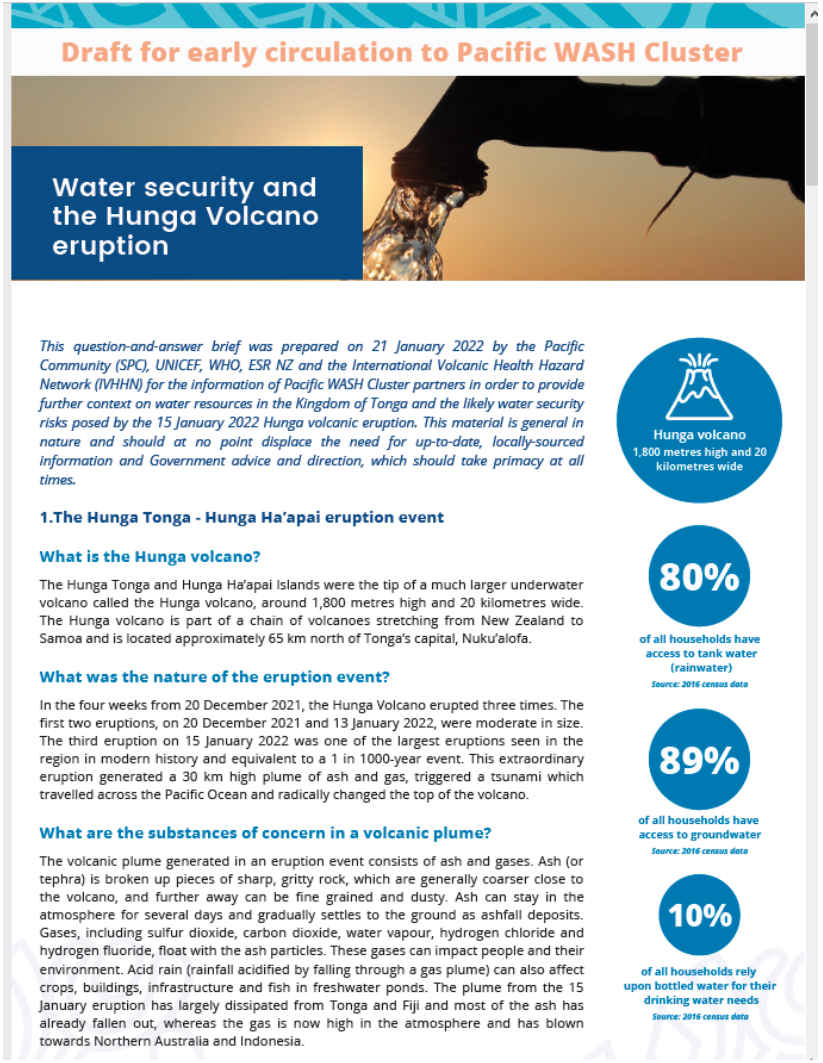
Areas of active and potential work

- Citizen Science – ash thickness was fruitless. NZ Tsunami and Airwaves questionnaire 3000 responses.
- Ash hazard characterization for:
  - Food security and agricultural recovery
  - Water supply security and health
  - Infrastructure
  - Ashfall clean-up
- Monitoring and support (volcano and tsunami)
- Event characterisation
  - Substantial NZVSAP member wide activity
- Risk assessment?
- Impacts (multi-hazard impact/loss modelling)
- Impacts (damage survey and fragility/vulnerability development) – renewed interest for tsunami.
- Cruise-based surveys – Kaharoa (shallow), Tangaroa, Koreans – all April?
- Shane's field work – April – Tongatapu interviews for timelines, photos, videos (pressure, tsunami, volcano), Tappen/Watt BGS sites beach profiles +advice from Jose and Bill. Ha'apai Group, Tangaroa (NERC)
  Task Canberra for more photos around vent.

Messaging
Generic (before ash analysed) → specific (once ash analysed)
Process: messages drafted, peer reviewed, translated, provided to MFAT and/or regional Clusters to pass on to Tongan government agencies

Input to Pacific WASH water security brief

- NZ input via ESR, NZVSAP and IVHHN
- TnT role in advising on water resources in Tonga



Draft for early circulation to Pacific WASH Cluster

Water security and the Hunga Volcano eruption

This question-and-answer brief was prepared on 21 January 2022 by the Pacific Community (SPC), UNICEF, WHO, ESR NZ and the International Volcanic Health Hazard Network (IVHHN) for the information of Pacific WASH Cluster partners in order to provide further context on water resources in the Kingdom of Tonga and the likely water security risks posed by the 15 January 2022 Hunga volcanic eruption. This material is general in nature and should at no point displace the need for up-to-date, locally-sourced information and Government advice and direction, which should take primacy at all times.

1.The Hunga Tonga - Hunga Ha'apai eruption event

What is the Hunga volcano?

The Hunga Tonga and Hunga Ha'apai Islands were the tip of a much larger underwater volcano called the Hunga volcano, around 1,800 metres high and 20 kilometres wide. The Hunga volcano is part of a chain of volcanoes stretching from New Zealand to Samoa and is located approximately 65 km north of Tonga's capital, Nuku'alofa.

What was the nature of the eruption event?

In the four weeks from 20 December 2021, the Hunga Volcano erupted three times. The first two eruptions, on 20 December 2021 and 13 January 2022, were moderate in size. The third eruption on 15 January 2022 was one of the largest eruptions seen in the region in modern history and equivalent to a 1 in 1000-year event. This extraordinary eruption generated a 30 km high plume of ash and gas, triggered a tsunami which travelled across the Pacific Ocean and radically changed the top of the volcano.

What are the substances of concern in a volcanic plume?

The volcanic plume generated in an eruption event consists of ash and gases. Ash (or tephra) is broken up pieces of sharp, gritty rock, which are generally coarser close to the volcano, and further away can be fine grained and dusty. Ash can stay in the atmosphere for several days and gradually settles to the ground as ashfall deposits. Gases, including sulfur dioxide, carbon dioxide, water vapour, hydrogen chloride and hydrogen fluoride, float with the ash particles. These gases can impact people and their environment. Acid rain (rainfall acidified by falling through a gas plume) can also affect crops, buildings, infrastructure and fish in freshwater ponds. The plume from the 15 January eruption has largely dissipated from Tonga and Fiji and most of the ash has already fallen out, whereas the gas is now high in the atmosphere and has blown towards Northern Australia and Indonesia.

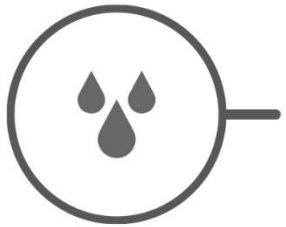
Hunga volcano
1,800 metres high and 20 kilometres wide

80%
of all households have access to tank water (rainwater)
Source: 2016 census data

89%
of all households have access to groundwater
Source: 2016 census data

10%
of all households rely upon bottled water for their drinking water needs
Source: 2016 census data

NGAAHI FAKAMATALA MAHU'INGA FEKAU'AKI MOE
EFU NE TO



Lolotonga hono fakama'a 'oe efu, 'oku fiema'u ke **tui ha malu'i lelei** (ko ha malu'i fofonga P2 pe N95, malu'i mata, vala pē kofu lōloa, kofunima mo e su mapuni).

'Oua te mou ngaue'aki 'a e vai ke fufulu 'aki 'a e efu mei he me'alele pe koe ngoue- koe 'uhi 'e maumau 'a e vai pea tene fakatupunga ai ke fefeka ange mo faingata'a hono fufulu.

'Oua kai ha fa'ahinga ika na'e tafia 'o hake 'ihe ngaahi matatahi. He 'ikai ke lahi ha ika ia 'e ma'u ofi ki he mata fonua pe ofi ki 'uta. Koe fangota he loloto pe moana 'e 'ikai u'esia ia.

Fakamama'o mei he fangota 'i he **potu tahi** 'oku uesia 'e he mo'unga-afi.

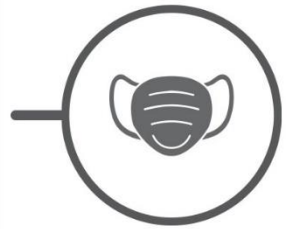
'Oku 'ilonga ia mei he lanu 'oe limu moe potu tahi 'oku nau 'iai.

'Oku 'ikai koha palopalema lahi 'ae 'uha 'esiti ki he vai inu.

Haka 'a e vai inu kotoa pe ke tamate'i 'ae siemu.

Kapau 'oku 'ikai ke 'i ai ha vai 'e taha 'oku sai pe ke ke **inu 'a e vai mei he 'uha.** Te ke lava 'o tuku ke nofo 'a e efu ki he takele 'o e tangike pe ko ha 'ai'anga vai pe sivi 'aki ia ha tupenu ma'a.

'To'o 'a e ngaahi fakatali mei he tangike vai kae 'oua leva ke ma'a 'a e efu mei he 'ato pea he 'ikai toe 'alu ha efu kihe loto tangike vai.

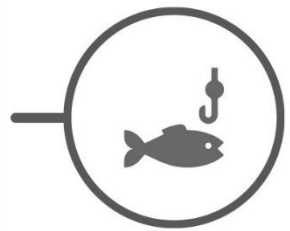


Faka'ehi'ehi mei he kai 'o e efu aki ha'o fakama'a 'a e me'atokoni kimu'a pea ke kai

'Oku malava pe ke ke **kai 'a e ngaahi ngoue** (hange ko e talo, kumala, manioke moe 'ufi.

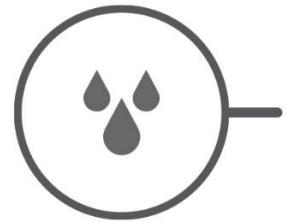
Ko e ngaahi me'akai 'oku 'i ai hano kili 'oku **sai 'aupito pe ia** ke ke kai (hange ko e meleni, lesi mo e mango).

Kapau 'e fio 'a e efu mo e kelekele 'e sai ia kihe mo'ui lelei 'a e ngoue pea ta'ofi ai mo e puhi holo 'a e efu 'ehe havili.



brought to you by

KEY MESSAGES FOR ASHFALL



For cleaning up ash, **wear good protective clothing** (if possible, a good face mask like P2 or N95, long clothing, goggles, shoes with closed toes).

Don't use water to wash ash off cars or off crops - this wastes water, and it may make the ash set into a hard layer that is harder to clean.

Don't eat any fish washed up dead on the shore. Coastal fishing catch rates are likely to be lower, but deep sea fishing should be unaffected. **Avoid** fishing in plumes of **seawater** that are **visibly contaminated** (coloured) from volcano run off.

Acid rain **should not** cause problems for drinking water.

Boil all drinking water to kill microbes.

If there is no other water, it is **safe** to **drink the rainwater**. You can let the ash settle to the bottom of the tank or a container or filter it through a clean cloth.

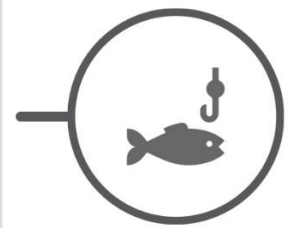
Disconnect pipes from rainwater tanks until ash is cleaned from roofs.

Try to **avoid** eating ash by cleaning it off food.

Root crops are **safe** to eat (like taro, kumala, manioke, yams/ufi).

Food that has a skin or peel is **safe** to eat (like watermelon, papaya and mango).

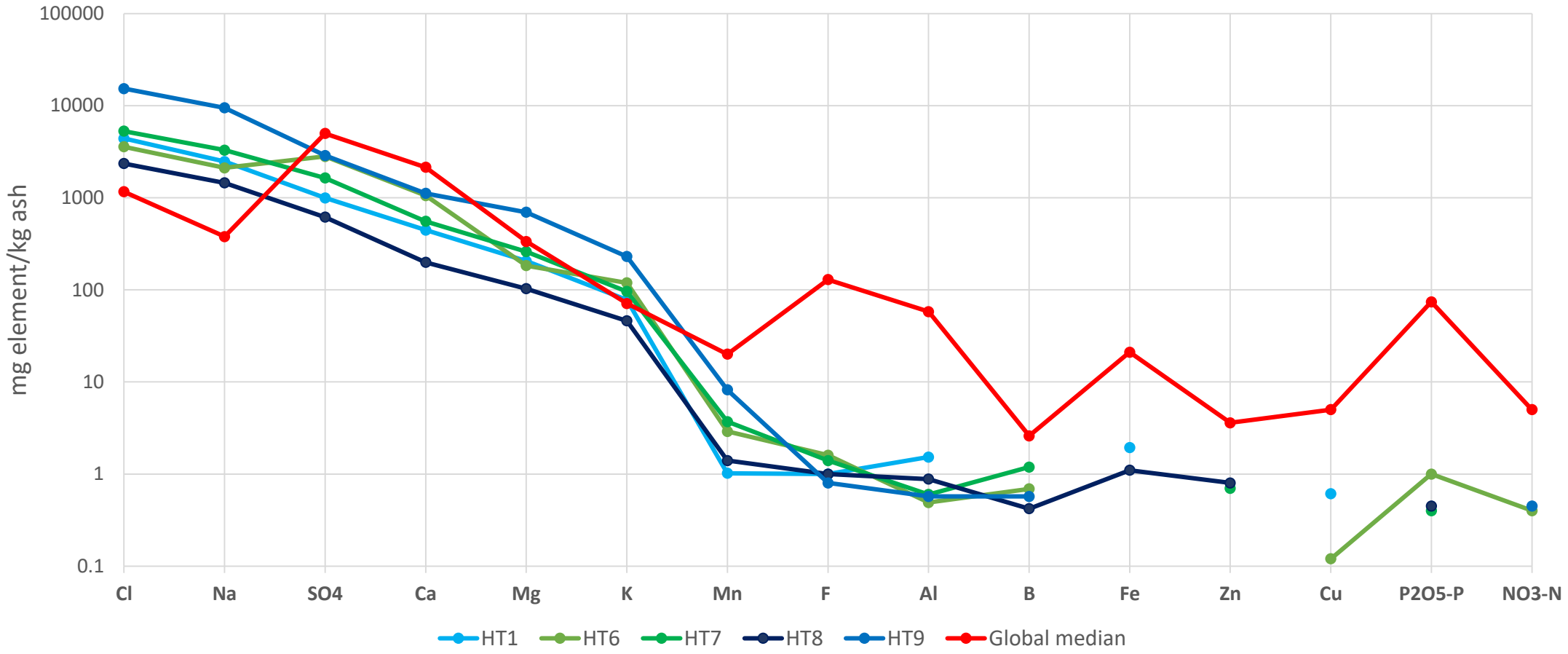
Working the ash into soil is good for fertility and limits it blowing around.



brought to you by


WHOLE MILK
COCO & COCONUT

Leachable element composition of Hunga ash



Leachable element properties of Hunga ash

- Not acidic
- Very high NaCl content
- Very low fluoride and trace metals

Management implications:

- Few issues for human or animal health (though animals should still be provided with clean feed)
- Few issues for rainwater tanks other than salty taste
- High Na may cause short to medium term issues for soil health – may need calcium-based soil amendments

GRADE report, GFDRR/World Bank 2022

Royal New Zealand Air Force P-3K2 Orion reconnaissance flight showing damages in Nomuka Island, Tonga
Photo Credit: New Zealand Defence Force

Table 1: Best estimate of direct damage[2] (values in TOP million).

	Residential Buildings (TOP m)	Non-Residential Buildings (TOP m)	Infrastructure (TOP m)	Agriculture, Forestry, Fishing (TOP m)	Total (TOP m)
Tongatapu	21.3	62.0	33.7	41.4	158.4
Ha'apai	8.7	2.5	3.9	2.5	17.7
'Eua	4.3	1.7	2.6	4.1	12.7
Cable	*0.0*	*0.0*	*7.8*	*0.0*	*7.8*
Subtotal	**34.3**	**66.3**	**48.0**	**48.1**	**196.7**
Ash Cleanup Costs		*11.3*			*11.3*
Total					**208.0**

Table 2: Best estimate of direct damage[2] (values in $US million).

	Residential Buildings ($m)	Non-Residential Buildings ($m)	Infrastructure ($m)	Agriculture, Forestry, Fishing ($m)	Total ($m)
Tongatapu	9.3	27.0	14.7	18.0	68.9
Ha'apai	3.8	1.1	1.7	1.1	7.7
'Eua	1.9	0.8	1.1	1.8	5.5
Cable	*0.0*	*0.0*	*3.4*	*0.0*	*3.4*
Subtotal	**14.9**	**28.8**	**20.9**	**20.9**	**85.5**
Ash Cleanup Costs		*4.9*			*4.9*
Total					**90.4**

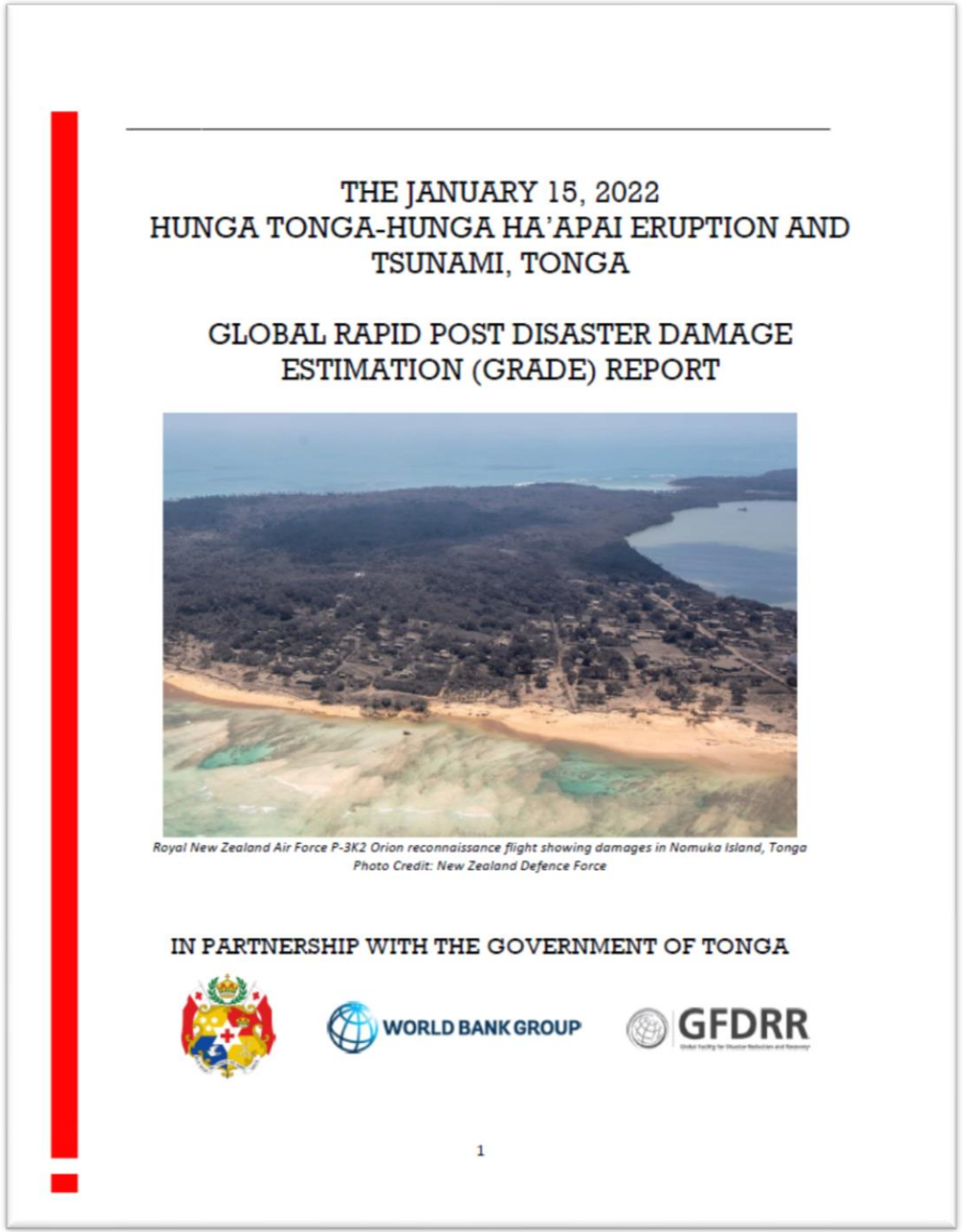
Table 3: Best estimate of direct damage[2] (as percentage of GDP based on World Bank staff estimates)

	Direct Damage (as percentage of country GDP)					
	Buildings		Infrastructure	Agriculture	Ash cleanup	Total
	Residential	Non-Residential				
Tonga	3.0%	5.9%	4.3%	4.3%	1.0%	18.5%

"Non-residential Buildings" include tourism-related buildings, health facilities, schools, public administrative buildings, religious buildings, commercial offices and private sector buildings.

GRADE report agricultural damage assessment:

- Impacts on agriculture:
  - 80% volcanic
  - 20% tsunami
- Est. $US 20.9 million direct damage to agriculture
- Low losses of root crops (cassava and yams)
- High losses of fruit trees and plants and leafy vegetables
- Some damage to commercial crops such as sandalwood
- Some loss of livestock



THE JANUARY 15, 2022
HUNGA TONGA-HUNGA HA'APAI ERUPTION AND TSUNAMI, TONGA

GLOBAL RAPID POST DISASTER DAMAGE ESTIMATION (GRADE) REPORT

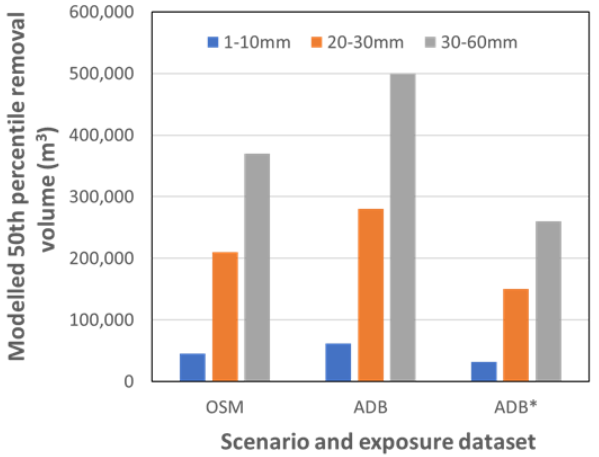
Royal New Zealand Air Force P-3K2 Orion reconnaissance flight showing damages in Nomuka Island, Tonga
Photo Credit: New Zealand Defence Force

IN PARTNERSHIP WITH THE GOVERNMENT OF TONGA

WORLD BANK GROUP GFDRR

1

Volcanic Ashfall Impact Assessment: **Tongatapu Clean Up Estimates**



- **Model**: Hayes et al. (2017) clean up model used to estimate clean up requirement on Tongatapu. Model informed by empirical data from previous ash clean-up operations from around the world.
- **Model inputs**
  - **Three** separate ash thickness scenarios used, due to ash hazard **uncertainty** at time of modelling.
  - Different **exposure** data sets used to illustrate potential exposure **uncertainty** (e.g., dataset completeness).
- **Results**:
  - 150,000-280,000m^3 of ash estimated requiring clean up on Tongatapu, assuming uniform 25mm ashfall thickness
  - A 30-60 mm ashfall yields 190,000-640,000 m^3
- **Assessment**
  - Despite uncertainty, all scenarios point towards a **considerable clean-up** effort being necessary to remove ash from affected communities:
  - Also potential for **highly mixed waste streams**:
    - Ash
    - Sediment/mud
    - Building debris
    - Vegetation

Thickness (mm)	Ash volume requiring removal (m³)		
	Roads	Roofs	Total
1-10	1,800 – 32,000	7,300 – 36,000	11,000 – 100,000
20 – 30	20,000 – 111,000	81,000 – 120,000	120,000 – 330,000
30 - 60	32,000 – 200,000	130,000 – 230,000	190,000 – 640,000

Some early lessons

- Value of pre-prepared messages/information for rapid sharing – cannot be overstated. NZ-developed resources (again) used widely, but probably need Pacific tweaks.
- Value of pre-existing networks and relationships was highlighted.
- Rapid ash analysis was key to providing targeted advice. Substantial challenges in obtaining pristine ash samples in a timely way.
- Water supply and ash clean up was more of a challenge than anticipated (again…)
- Potential (lost?) opportunities:
  - TnT active in Pacific and advising – unclear if connection to NZVSAP (two way learning)
  - Aid focus from MFAT – probably fair enough. Opportunity for more capability and capacity building projects on volcano resilience in Pacific