Risk Profile – Fiji 2016 Tropical Cyclone Reanalysis

1. **The Fiji built capital stock for residential and non-residential sectors has been shown to be around $6.5 billion**
2. **A reanalysis of the 2016 cyclone Winston mimics the results of the PDNA very well, with similarities seen in the residential and non-residential loss estimates. This shows the ability of the model to work in future events.**
3. **Much analysis of wind speeds and station data showed significant differences to other modelled results post-event.**

Why are we looking at Fiji

- The country has had very few country-level risk studies done, with largely differing estimates of built capital available via existing natural hazards scenarios and PDNAs.
- With such a big difference, detailed analysis was undertaken on the exposure side to resolve the capital value of assets.

Why is this useful to the TTL?

The Fiji scenario is useful to inform the GFDRR and TTLs of a model check of the PDNA result as well as giving some background as to the potential losses in the residential and non-residential sector.

Why are we doing the disaster scenario?

The "Disaster Scenarios" Fiji cyclone model can be applied to a probabilistic or deterministic modelling effort in the future. The building of this model allows for future events to be quickly analysed and losses to be determined more easily in the residential and non-residential sector. By reviewing the loss differences today vs. at the time of the event, a full suite of scientific studies, knowledge and expertise has been used, which benefits the production of exposure, hazard and vulnerability models for tropical cyclones anywhere around the world.

Background and historic losses

The 2016 Cyclone Winston

Disaster Type	Hurricane		**Deaths**	46
Magnitude and Location	Cat. 5 (Fiji)		**Homeless**	55,000
Date	20/02/2016		**Houses existing at time**	178,231
Country Population at Time	896,500		**People in dam./destr. houses**	156,936
Capital Stock at Time (Res.) - $USDmn	4,094		**Houses destroyed**	11,500
Capital Stock at Time (Non-Res.) - $USDmn	2,411		**Houses damaged**	19,700

The economic loss of the event from the PDNA suggests a value of $356 million in the residential sector and around $101 million in the non-residential sector.

How did we remodel the scenario?

Historic damage data, wind intensity maps and weather stations were examined in order to gain the best possible reanalysis of the scenario. The weather station data showed some of the issues in using a simplified best track data, with the wind speed model being checked against damage. This was very different in comparison to tracks created either via best track data, or through GDACS JRC.

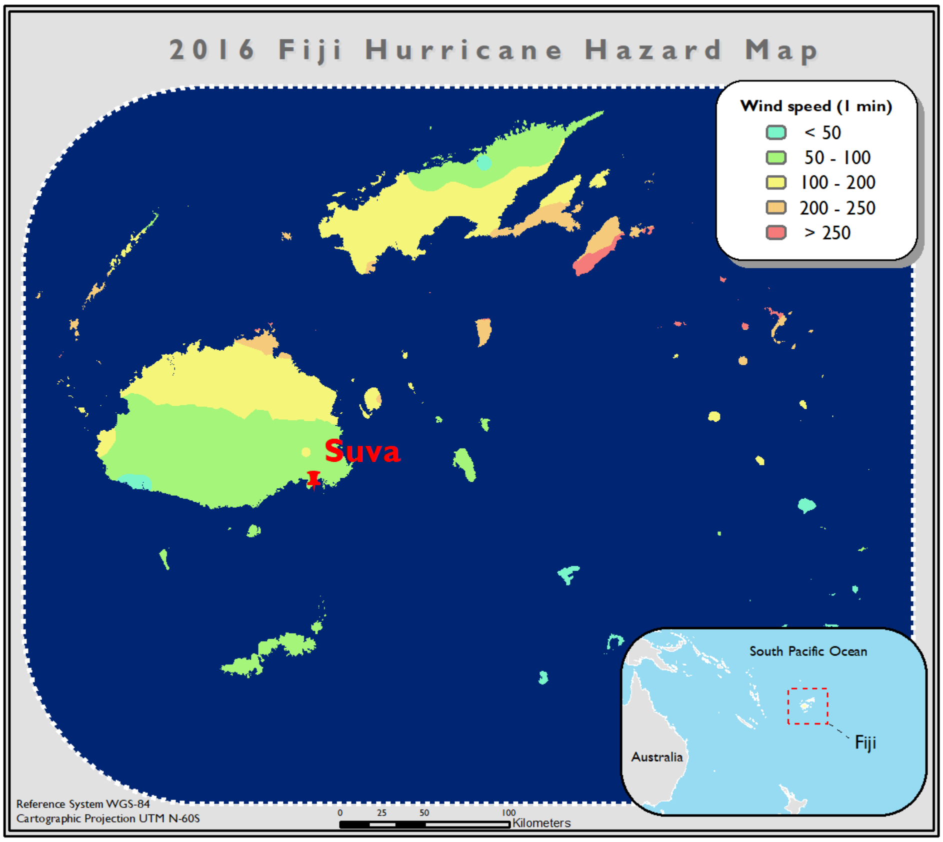

Figure 1: 1-min sustained wind speeds for the 2016 Winston Fiji Tropical Cyclone calibrated via station data and remodelled using calibrated wind fields.

The assessment of the Fiji residential and non-residential buildings exposure at the time of Tropical Cyclone Winston (February 22, 2016) was done at the resolution of the Enumeration Areas (EA). There are 1602 EA's in Fiji. The outer wall data of the 2007 Fiji Population and Housing Census were used to characterize the housing stock. Unfortunately, the crucial to cyclone risk, information on roof cover types is not included in the Fiji census. EA population was projected to 2016 but the households are distributed by outer wall type as per 2007 census. It was assumed that one household corresponds to one dwelling unit. The dwelling size (in square meters) and unit cost of construction (USD per square meter) for each typology were taken from the PDNA report. For the non-residential buildings exposure each EA was characterized as capital region, other urban area or rural area and appropriate non-residential to residential built floor area ratios were used (based on analysis of the PCRAFI building footprints). The non-residential built floor area is distributed to Commercial, Public and Industrial occupancy. The exposure is adjusted to the Gross Capital Stock of Fiji allowing for devaluation of older buildings. The exposure sums to 4094 million USD for residential buildings (Fig. 2) and 2411 million USD for non- residential buildings. In Fig. 3 the EA-level per capita residential exposure is shown. It ranges between 1515 and 12430 USD as it is influenced by the house typologies, dwelling sizes and the mean size of the households in each EA.

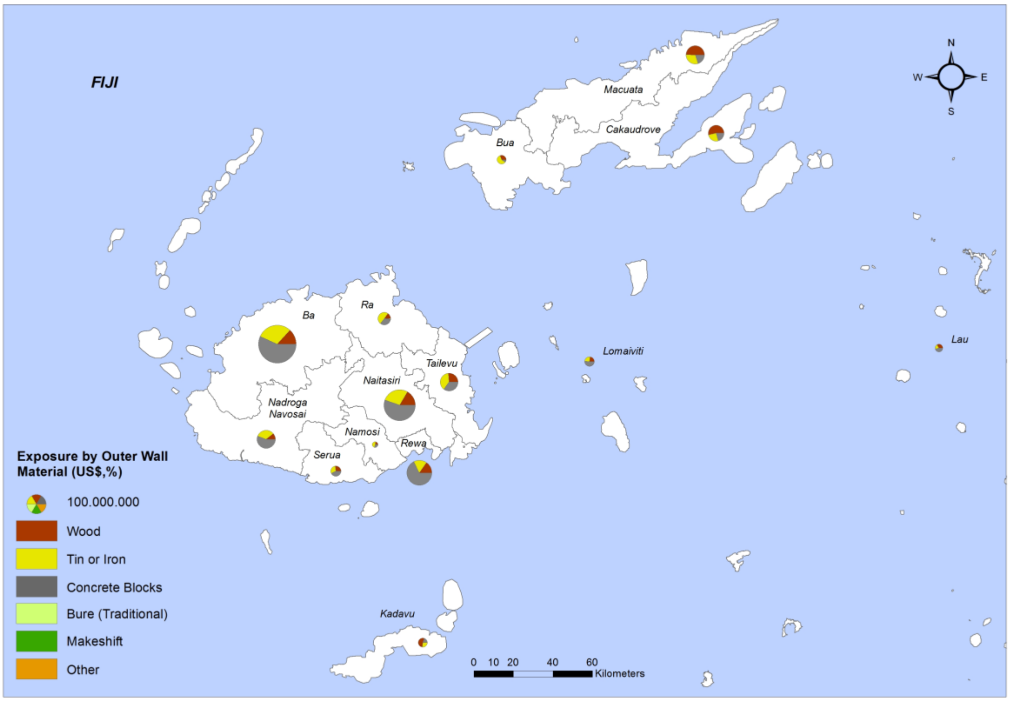

Figure 2: Residential exposure in Fiji. The map shows the size of the exposure in USD (scaled pie charts) and the breakdown into outer wall typologies in each province (Rotuma province is not shown).

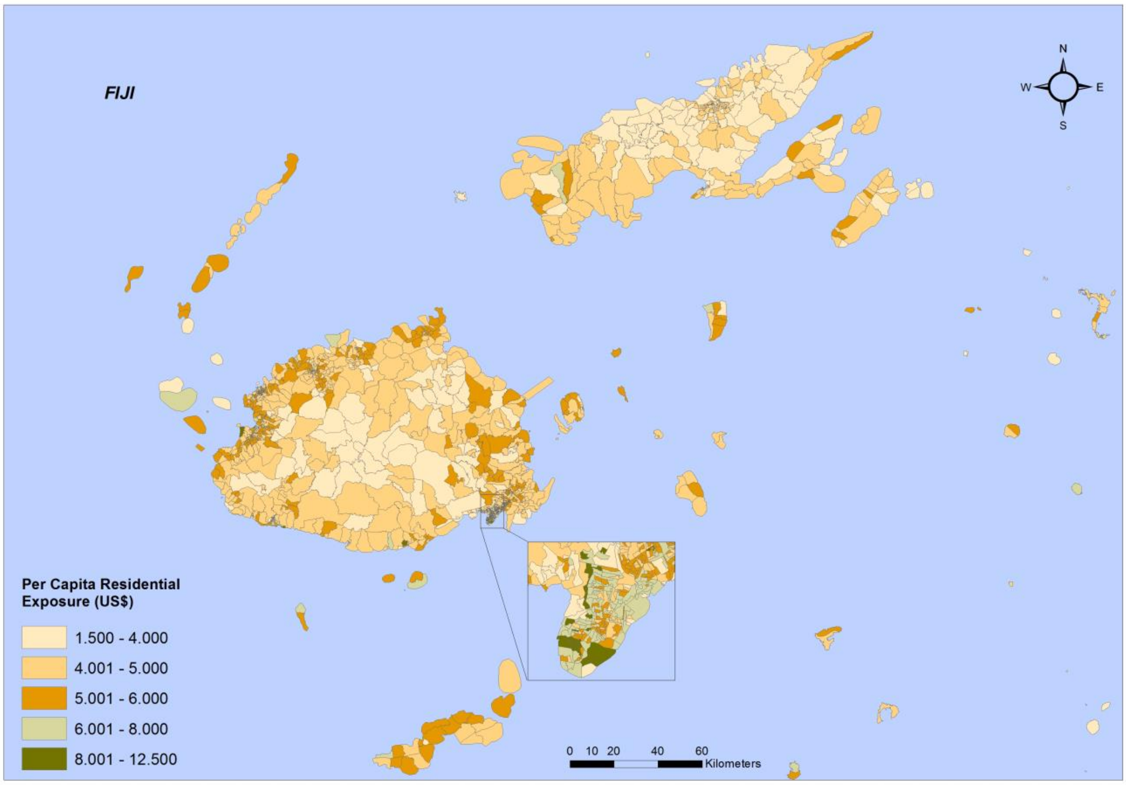

Figure 3: Per capita residential exposure in Fiji (in USD) at the enumeration area level (Rotuma province is not shown).

The **vulnerability** of the built structures was characterised using hazard-damage curves calibrated via this event using a suite of functions from around the world from past events for similar building typologies. This was built on the basis of mostly 1-min wind speed data (without gust speeds), however unfortunately very little data has been recorded given that very few stations are generally present in high wind speed areas. A lognormal vulnerability function was thus fitted to certain location data and a beta distribution can be used to extract the number of destroyed houses. It is important to note that there is often a large scatter in damage states in TC modelling.

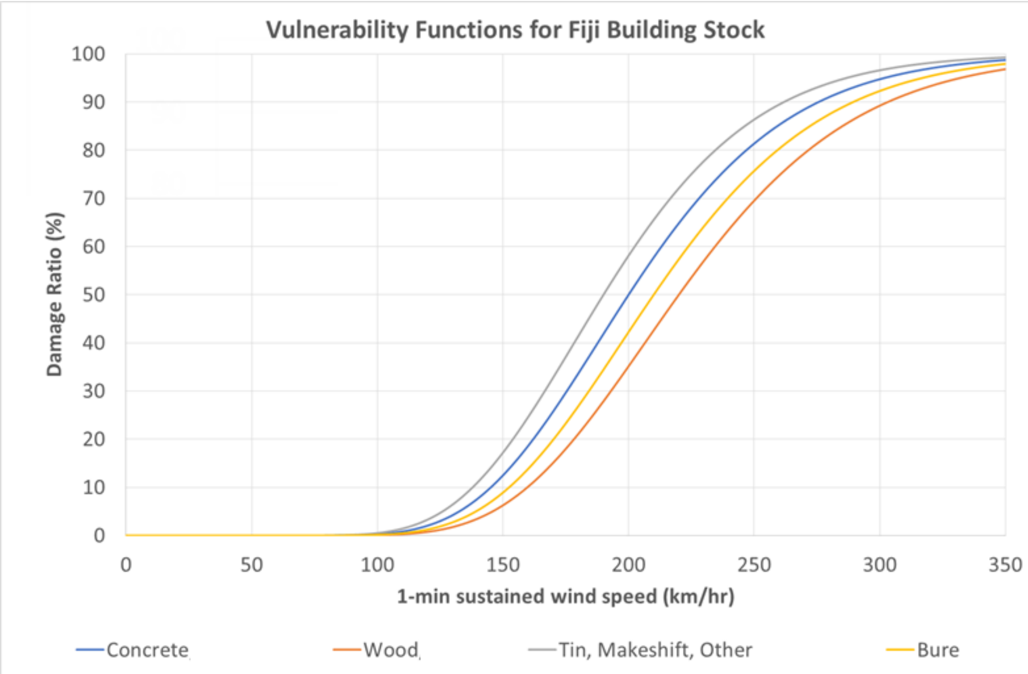

Figure 4: Vulnerability curves for Fiji

The **vulnerability** of the built structures to wind was characterised within various projects including ERN, Sparks et al. (1994), Hart, Unanwa et al. (1999), AIR, Pita et al. (2014) and also previous CDRP analyses. These were aggregated from similar functions for each building typology.

What are the potential losses due to the reanalysis?

	Historic	Modelled
Residential Damage (mn USD)	356	336
Residential Stock (mn USD)	4094	4094
Exposed Res. Stock over 100kph (mn USD)		1908
Residential Loss Ratio	8.70%	8.20%
Non-Residential Damage (mn USD)	101	132
Non-Residential Stock (mn USD)	2411	2411
Exposed Non-Res Stock over 100kph (mn USD)		1024
Non-Residential Loss Ratio	4.19%	5.47%

The **potential losses** mimic the values of loss very closely for the residential portion of losses. In terms of the non-residential losses, higher values were seen in our analyses, likely due to the exposure assumptions used.

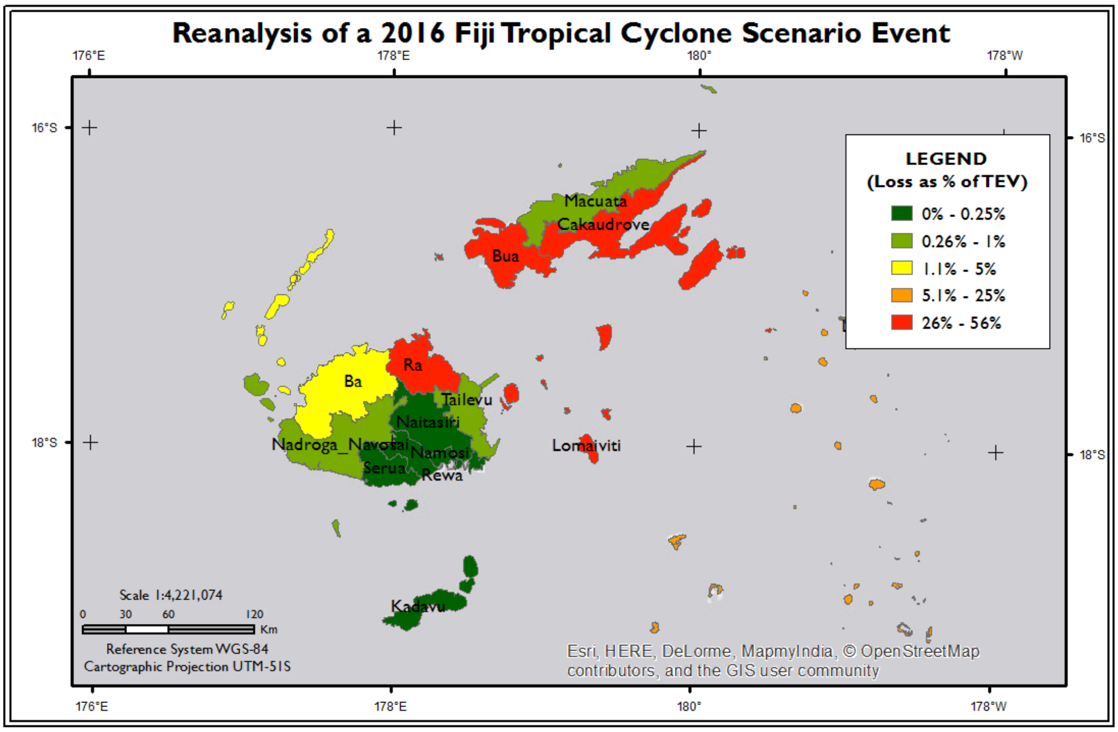

Figure 5: Relative losses on an administrative level 1 unit (regions) (Loss as a % of Total Exposure Value)

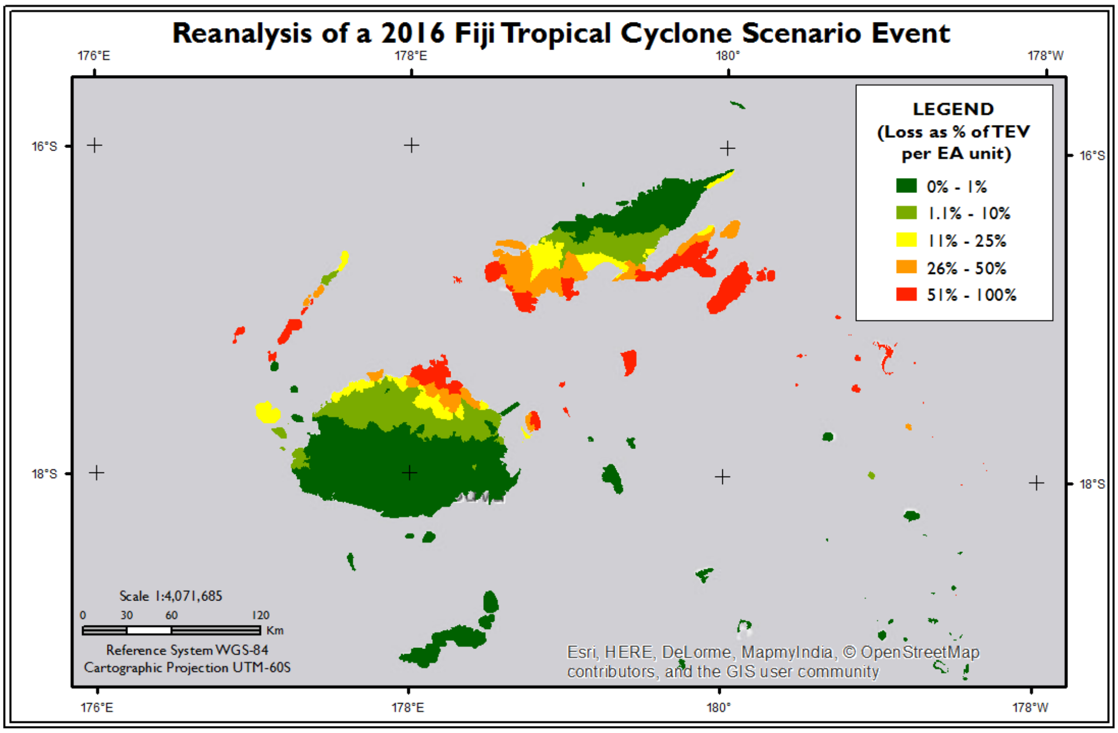

Figure 6: Relative losses as a 1km resolution per EA unit

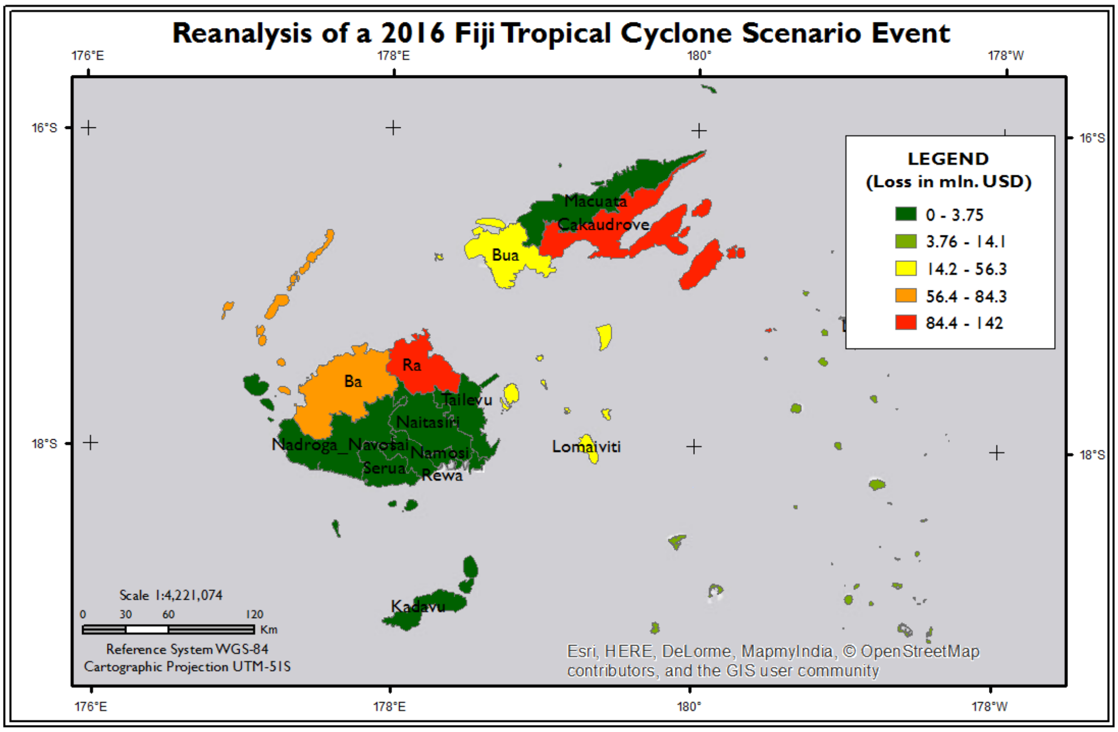

Figure 7: Absolute losses as an administrative level 1 division

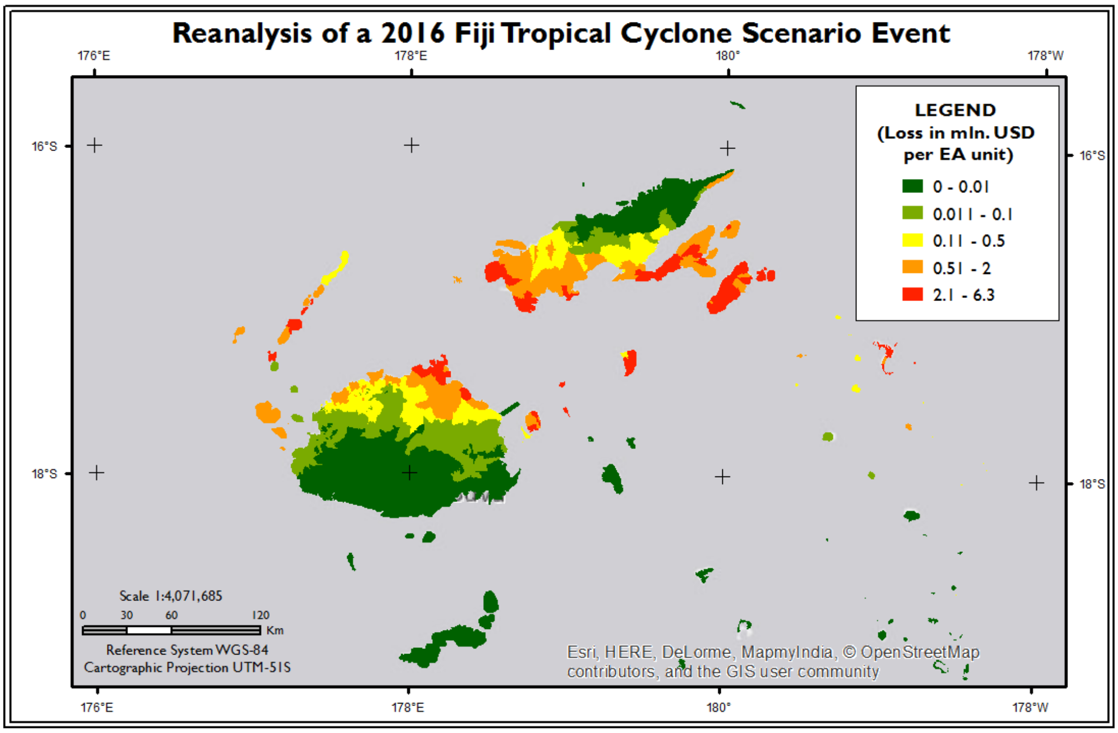

Figure 8: Absolute losses at an EA Unit level in million USD

Province	Total Exposure (mn USD)	Total Loss (mn USD)	Total Loss Ratio	Residential Exposure (mn USD)	Residential Loss (mn USD)	Non-Res Exposure (mn USD)	Non-Res Loss (mn USD)
Ra	207.80	116.73	56.17%	136.2	82.1	71.6	34.6
Lomaiviti	116.30	56.30	48.41%	76.8	39.3	39.5	17.0
Cakaudrove	314.80	142.00	45.11%	207.3	98.0	107.5	44.0
Bua	99.10	42.79	43.18%	66.0	31.5	33.1	11.3
Lau	74.20	14.11	19.02%	50.2	9.7	24.1	4.4
Ba	1869.30	84.33	4.51%	1203.1	65.9	666.2	18.5
Nadroga Navosai	413.60	3.75	0.91%	275.2	3.0	138.5	0.8
Tailevu	396.50	3.18	0.80%	258.0	2.6	138.4	0.5
Macuata	442.30	2.43	0.55%	284.9	1.9	157.4	0.5
Naitasiri	1363.50	1.60	0.12%	812.6	1.4	550.9	0.2
Rewa	917.70	0.52	0.06%	530.1	0.4	387.6	0.1
Kadavu	77.70	0.03	0.04%	52.4	0.0	25.3	0.0
Namosi	43.70	0.01	0.02%	29.0	0.0	14.8	0.0
Serua	130.40	0.02	0.02%	86.0	0.0	44.5	0.0
Rotuma	37.70	0.00	0.00%	25.7	0.0	12.0	0.0

What is the return period of such a loss an event?

Using the PCRAFI risk profile and scaling for the changed exposure, given the difference in capital stock estimation ($18.865 bn for buildings in 2010), the loss value of $468 million is given a mean return period of around 1000 years in the loss curve, which seems very high considering that historically many events have passed over Fiji, and that in this event Suva was not greatly affected.

On the basis of historical records, around 50-100 years would be a more reasonable return period, if not lower, for the 2016 Winston cyclone loss on an EP curve.

Using the wind curve from GAR2015, the windstorm risk scaling up the losses by 1.779 to account for the exposure difference would give an expected loss of $832m. On the GAR2015 curve, this would be a 69-year event.

Why was it important to collate the data?

The 2016 Winston event had some station data which had not been utilised as part of a reanalysis of the wind field previously. Considering that original JRC and risk modelling firm maps did not match up well with damage reports, checks were made and a new wind field estimation made for the event.

Similarly on the exposure side, much work was needed in order to resolve the economic exposure of the built capital with this estimation being in excess of 3 times less than that of the PCRAFI study of 2014.