Risk Profile – Haiti 2010 Earthquake Reanalysis

1. **A reanalysis of the Haiti 2010 earthquake shows that economic damage in the residential and non-residential stock would be in the order of**
2. **A nationwide exposure model has been produced for Haiti's stock which was used as part of the CDRP risk model and Hurricane Matthew 2016 analysis.**

Why are we looking at Haiti

- Haiti has had very few country level risk studies, with largely differing estimates of built capital available via existing natural hazards scenarios and PDNAs.
- A difference in per capita capital and building typologies is seen across the country, as well as the quality of the buildings, thus meaning that the relative vulnerability changes significantly and needs to be carefully explored.
- Given a large number of unknowns from the 2010 earthquake, a reanalysis gives possible indications as to the losses associated with such an event and a good litmus test as to the potential future losses.

Why is this useful to the TTL?

The Haiti 2010 earthquake reanalysis is useful to inform the GFDRR and TTLs of a model check of the original PDNA result as well as giving some background as to the potential losses in the residential and non-residential sector and the change in vulnerability within the area of losses back in 2010.

Why are we doing the disaster scenario?

The "Disaster Scenarios" Haiti earthquake 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 earthquakes anywhere around the world.

Background and historic losses

The January 12, 2010 Haiti earthquake was one of the most devastating earthquakes in recent times. The M_W7 earthquake occurred on the eastern end of the Enriquillo-Plantain Garden fault zone and very near the capital city of Port-au-Prince. It devastated many parts of the city such as Gressier, Pétion Ville, Carrefour, Cité Soleil, Delmas, the commercial district near the port as well as neighbouring Leogane and Grande Goave.

Disaster Type	Earthquake		**Deaths***	ca. 80,000
Magnitude and Location	Mw7.0 (S. Haiti)		**Homeless**	700,000 to 2,200,000
Date	12/01/2010		**Houses existing at time**	2,281,839
Country Population at Time	9,926,000		**People in dam./destr. houses**	1,363,869
Capital Stock at Time (Res.) - $USDmn	16,082		**Houses destroyed**	105,369
Capital Stock at Time (Non-Res.) - $USDmn	7,997		**Houses damaged**	208,164

How did we remodel the scenario?

The USGS Shakemap was analysed, however it was found to be erroneous given a study of Mora and McCann (2010) being used, and showing much damage in parts of Haiti, where there was no damage reported (e.g. L'Artibonite, Centre and Nord-Ouest departments). Thus, intensity measurements in locations such as Port-au-Prince as well as ground motion reanalysis from authors like Hough (2012) were taken into account in the production of MMI, PGA and PSA ordinate maps. As the strong motion observation network in Haiti in 2010 was very sparse, spatial differences in ground motion are not well documented and thus soil effects were taken into account but detailed spatial discretisation of hazard was not undertaken.

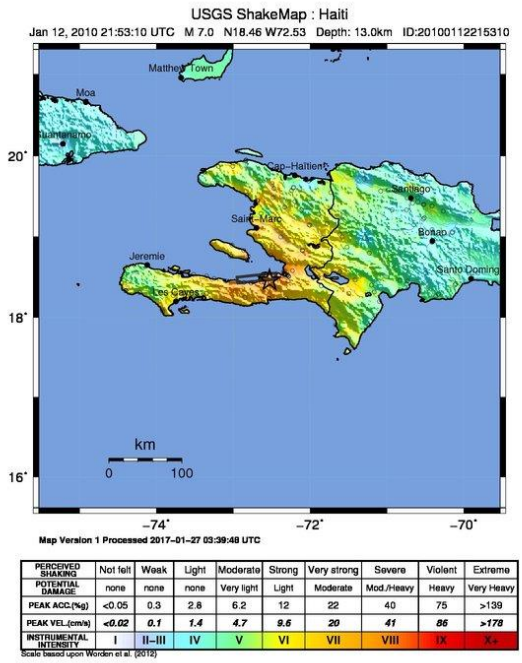

Figure 1: Erroneous Shakemap not taken into account

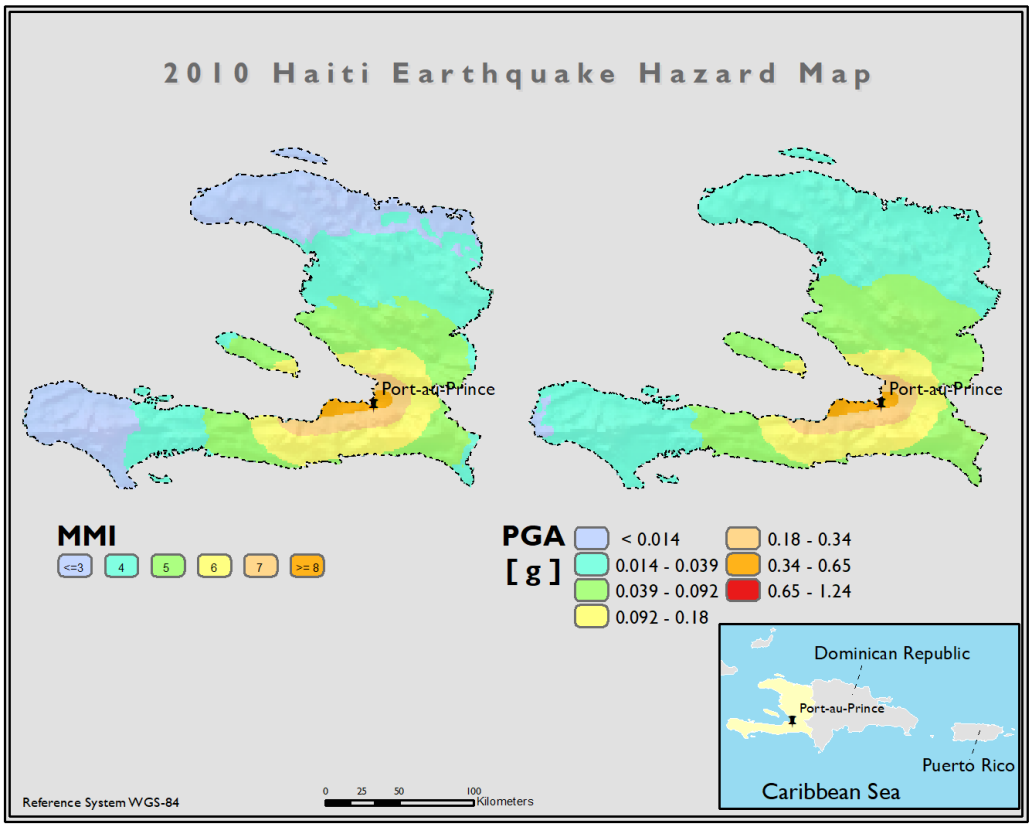

Figure 2: MMI and PGA maps indicating the hazard component of the Mw7.0 earthquake as representatively remodelled in this study.

The Haiti building stock exposure was built from various sources including the last Population and Housing Census of Haiti (IHSI, 2003), the post-earthquake surveys and ECVMAS-2012 (a post-

earthquake living conditions survey). Eight building classes were created along the lines of these studies via the census and survey information. The spatial differences in typologies can be seen in Table 3 showing around 79% of the total residential exposure in houses with concrete outer walls (concrete block and poor concrete aggregate) and brick housing. Non-residential stock as a proportion as total stock is highest in Ouest Department (Port-au-Prince/Carrefour), but the main difference is in the size and typology of the building stock.

Table 1: Departmental and building type breakdowns for the Haiti residential (by outer wall) and non-residential exposure incl. building contents

Department	Wooden	Earthen	Concrete	Plastic	Brick	Metal	Clisse	Other	Non-Residential	Total
Centre	193	16	416	1	73	13	5	10	219	**948**
Grand'Anse	28	14	336	0	59	27	3	20	133	**620**
L'Artibonite	28	47	2580	1	459	87	7	21	1015	**4244**
Nippes	16	9	386	0	68	19	1	11	89	**600**
Nord-Est	41	15	433	0	76	3	1	13	242	**825**
Nord-Ouest	14	13	872	2	157	29	2	30	229	**1351**
Nord	27	30	1610	2	282	14	5	32	1019	**3022**
Ouest	160	10	8542	31	1586	44	10	16	6982	**17380**
Sud-Est	79	6	634	2	116	37	5	10	246	**1133**
Sud	11	18	969	1	170	36	5	17	355	**1581**
Total	**596**	**179**	**16779**	**40**	**3046**	**309**	**45**	**180**	**10530**	**31704**

*all values in million USD

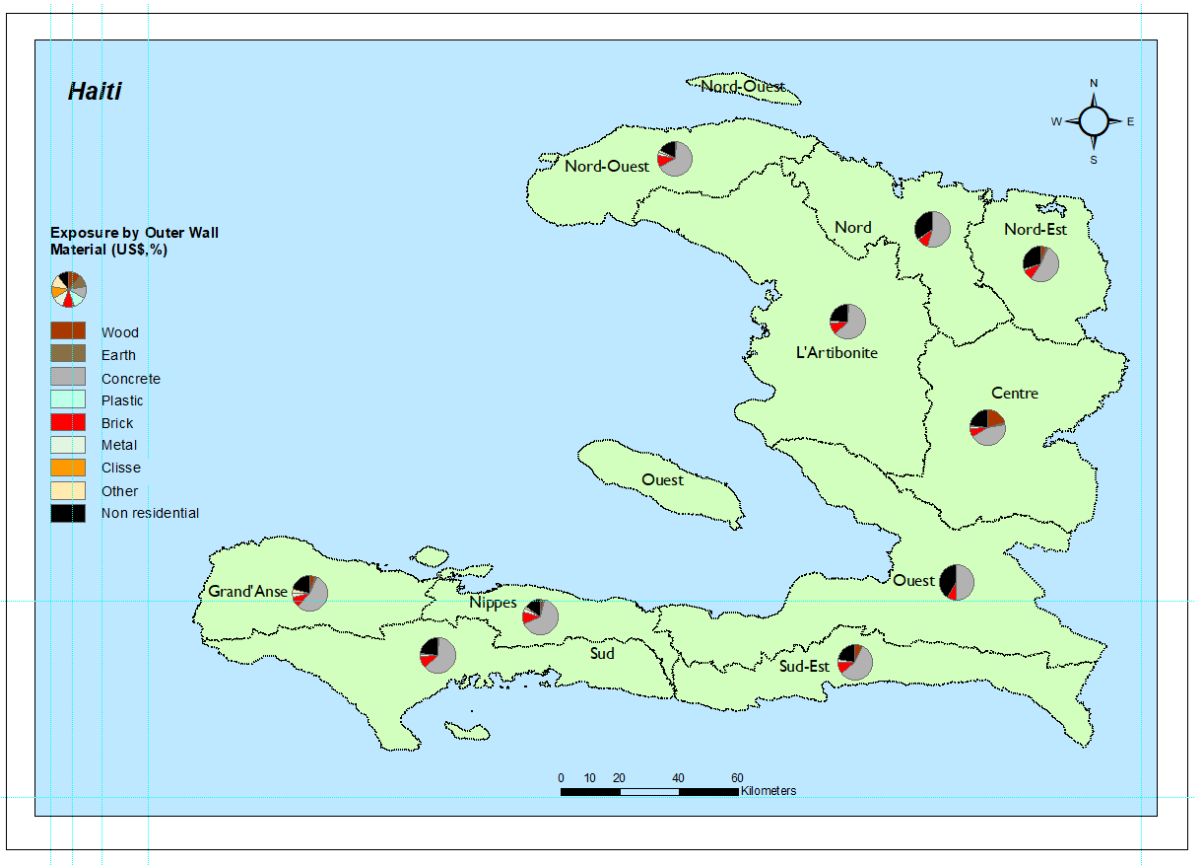

Figure 3: Exposure showing departmental breakdown of building types.

Given the large number of building typologies due to engineered and non-engineered design, lumped vulnerability functions were examined for the exposure in order to resolve the losses when derived into PGA-based functions. These were calibrated versus the Haiti 2010 event as much as was possible with the limited data available.

The **vulnerability** of the built structures was characterised within various projects including post-disaster surveys from Haiti; Molina et al. (2013) and informed by functions from neighbouring countries in the Caribbean as constructed during the CDRP Risk Profile process.

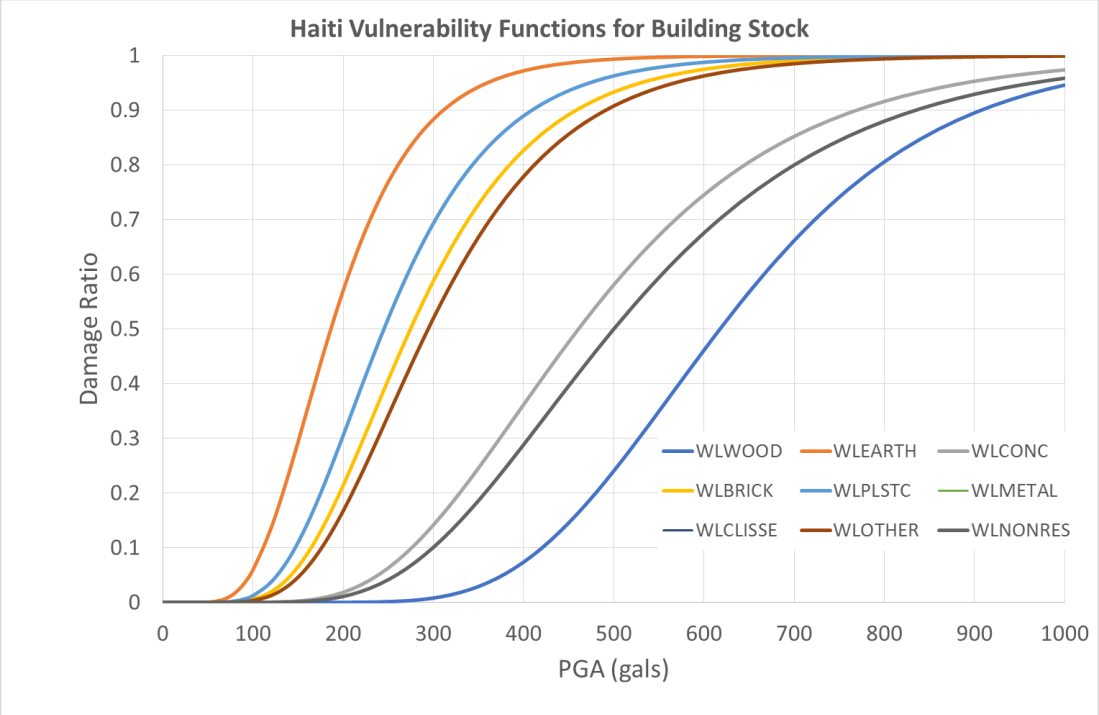

Figure 4: Haiti Vulnerability Functions for building stock

What are the potential losses due to the reanalysis?

	Historic	Modelled
Residential Damage (mn USD)	2333	3184
Residential Stock (mn USD)	16082	21174
Exposed Stock (mn USD) over MMI6		12550
Residential Loss Ratio	14.51%	15.04%
Non-Residential Damage (mn USD)	975	1391
Non-Residential Stock (mn USD)	7997	10530
Exposed Stock (mn USD) over MMI6		7546
Non-Residential Loss Ratio	12.19%	13.21%

The following diagrams indicate the absolute and relative loss (including contents) for a similar scenario to that of the 2010 Haiti event, with the losses on a square kilometre spatial resolution, and also on an administrative level 1 and level 2 division. Most of the losses were seen around Port-au-Prince and in the Ouest department.

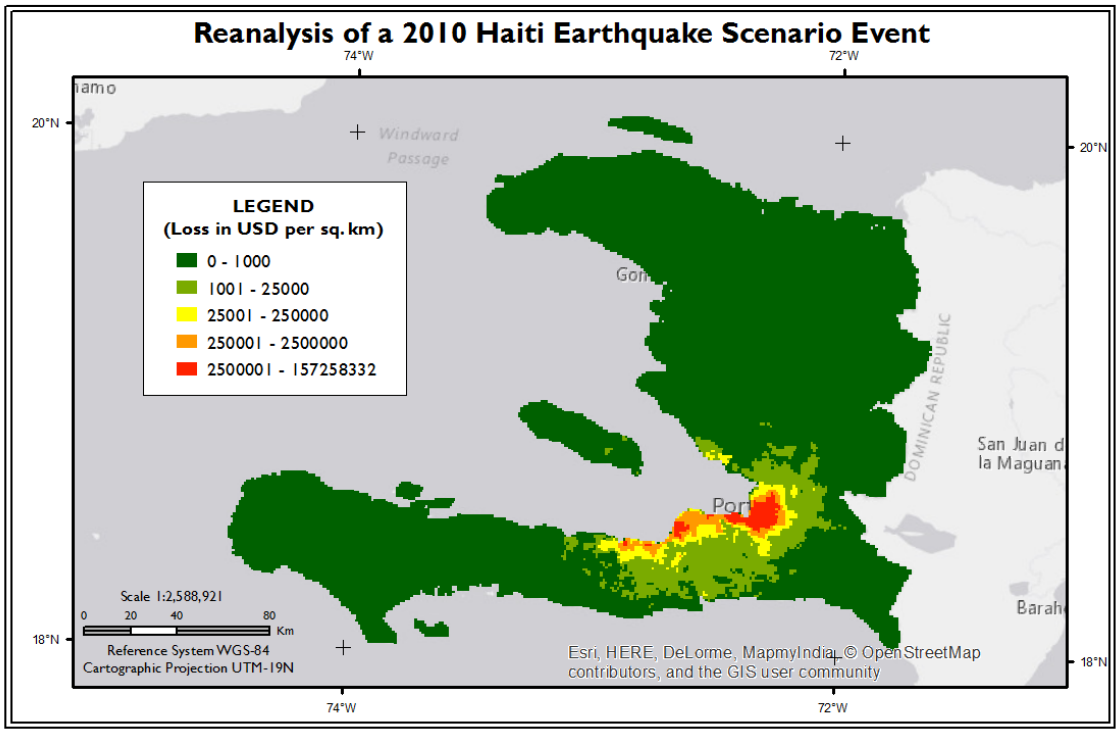

Figure 5: Absolute loss on a 1km resolution for the reanalysis

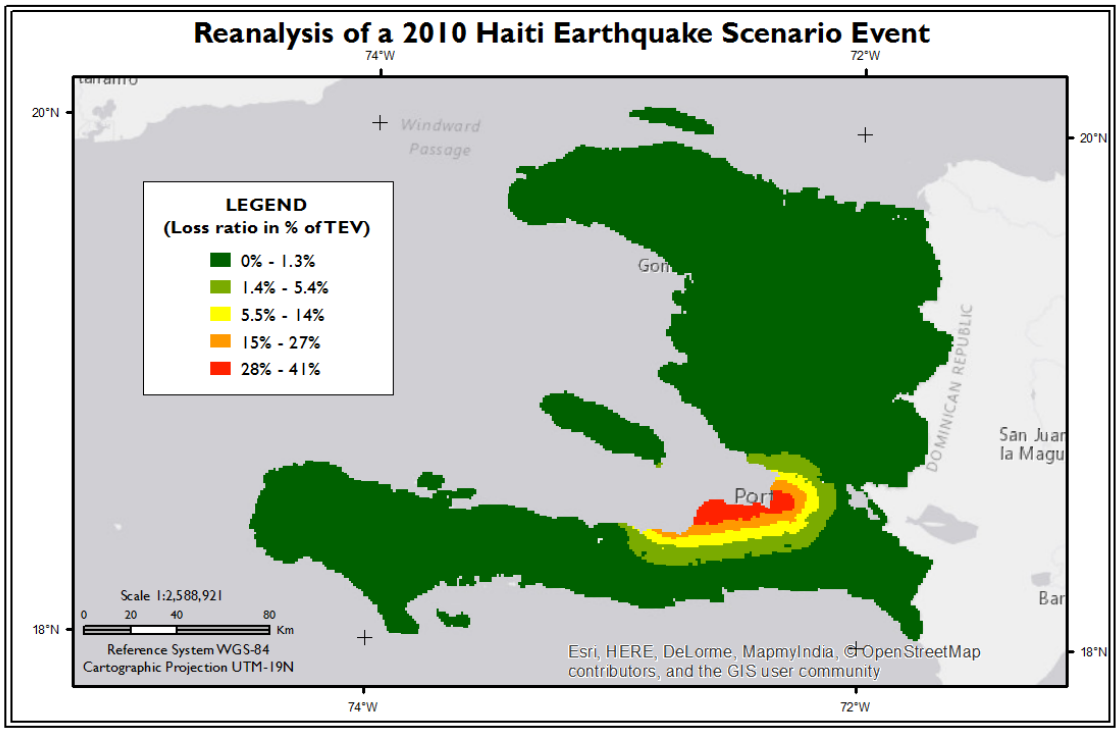

Figure 6: Relative loss on a 1km resolution for the reanalysis as a % of total exposed value

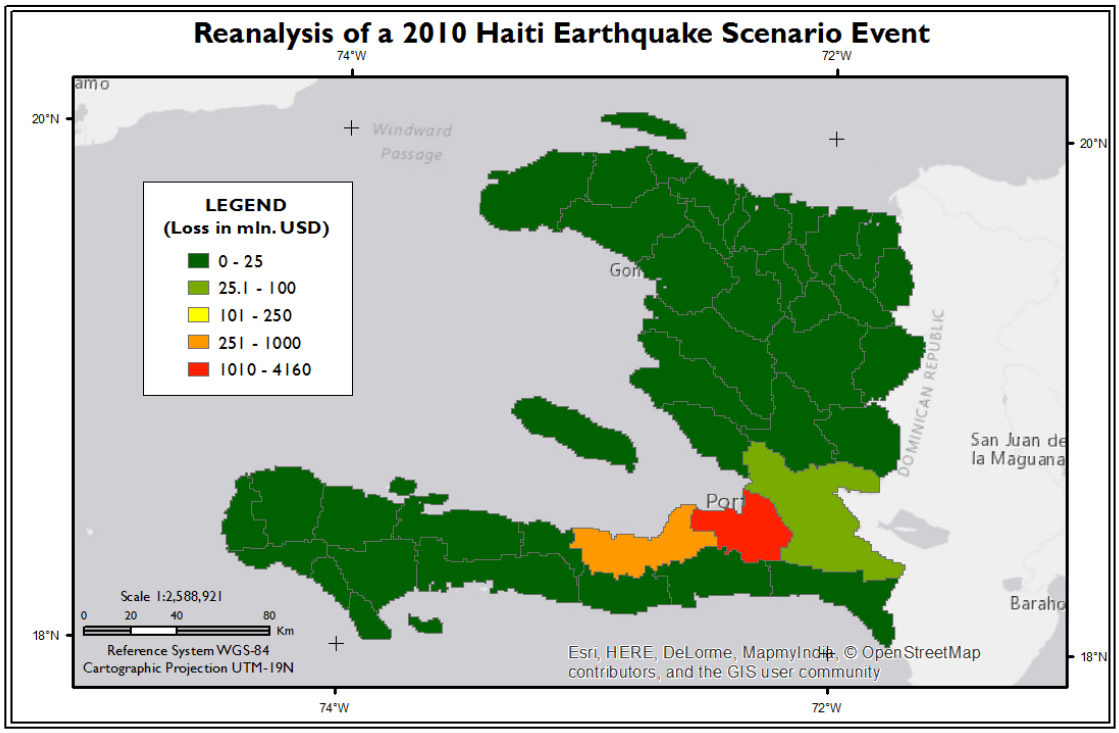

Figure 7: Absolute loss on an administrative level 2 for the reanalysis

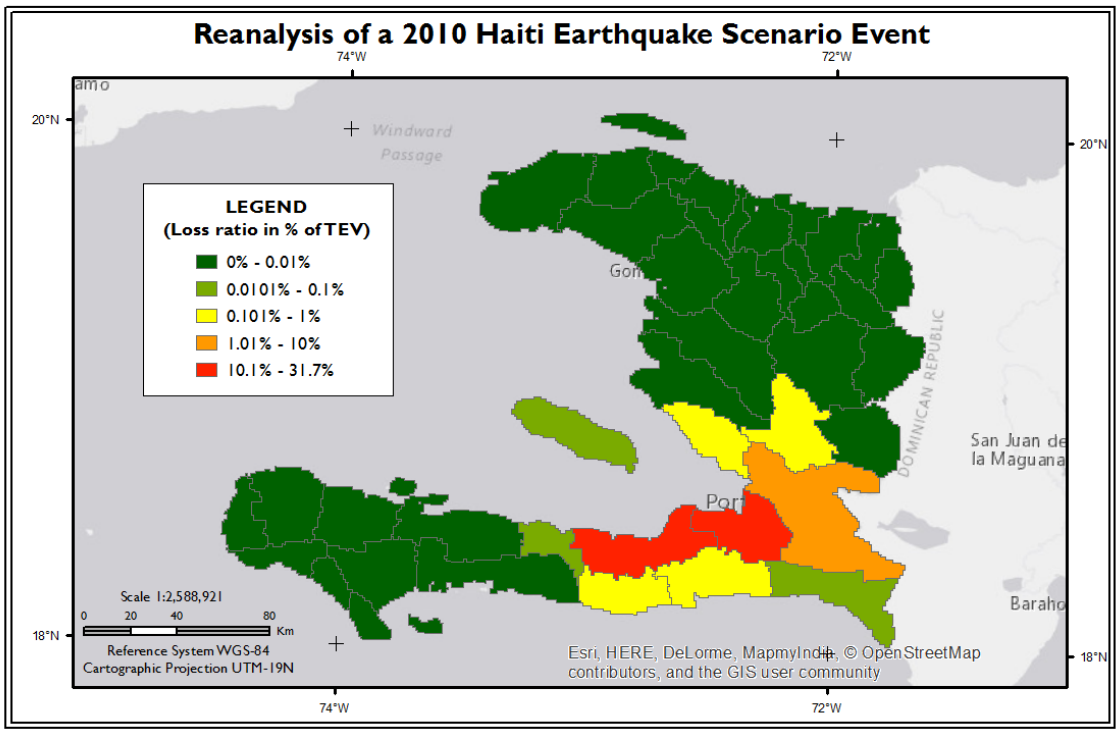

Figure 8: Relative loss on an administrative level 2 for the reanalysis as a % of total exposed value

What is the return period of such an earthquake loss in Haiti?

Using the CDRP Risk Profile, this reanalysis would put the losses on around a 1000-year return period. Due to the position of the earthquake, proximity to the highest concentration of capital in Haiti; this is one of the highest loss scenarios expected as a result of movement on the Enriquillo–Plantain Garden fault zone near Port-au-Prince. GAR2015 has the return period of loss at around 400 years.

Why was it important to collate the data?

The 2010 Haiti event was an event where there was a significant amount of uncertainty post-disaster as to building costs, exposure, inventory, damage data, loss data as well as vulnerability, and even looking at the USGS shakemap, on the hazard modelling side. However, this meant that there were also many conflicting numbers post-disaster.