Risk Profile – Pakistan 2010 Flood Reanalysis

1. **The Pakistan floods destroyed 913,000 houses with 90% of these being poor quality temporary/semi-permanent housing which shows up in the reanalysed replacement cost for the event of $2,436mn which comes out to around 14% higher relatively to 2010.**
2. **Analysis of population in 2000 and 2015 within the flood zones showed that it had increased at more than double the rate compared to the overall Pakistan population, indicating an increased risk of future loss. Furthermore in 2015 nearly 8.8% of the country's population (16.6 million) lived within the flooded areas plus a 1-km buffer zone around them**
3. **A nationwide exposure model has been produced for Pakistan's residential stock for use in future risk analyses.**

Why are we looking at Pakistan

- The country has had very few risk studies done on the entire country, with largely differing estimates of built capital available via existing natural hazards scenarios and PDNAs.
- Building typologies differ greatly across the country meaning that relative vulnerability changes significantly and needs to be explored.
- A comparison with the earthquake impact of 2005 can be gleaned for the same country.

Why is this useful to the TTL?

The Pakistan floods 2010 analysis 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 sector in Pakistan and the change in vulnerability within the area of losses back in 2010.

Why are we doing the disaster scenario?

The "Disaster Scenarios" Pakistan flood 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 gambit of scientific studies, knowledge and expertise has been able to be used, which benefits the production of exposure, hazard and vulnerability models for floods anywhere around the world.

Background and historic losses

Disaster Type	Flood		**Deaths**	1,985
Magnitude and Location	Indus River		**Homeless**	ca. 8,000,000
Date	July-Sep 2010		**Houses existing at time**	26,832,025
Country Population at Time	170,920,000		**People in dam./destr. houses**	10,163,729
Capital Stock at Time (Res.) - $USDmn	119,849		**Houses destroyed**	913,307
Capital Stock at Time (Non-Res.) - $USDmn			**Houses damaged**	694,878

How did we remodel the scenario?

Flood footprint data was examined and a reanalysed simplified basin fill model was undertaken vs. the DEM and the flood extents in order to create flood depths along the areas. This holds inherent uncertainties given the 30m DEM used, however provides a simplified view. The entire analysis is highly dependent on the flood extents, but also on the vertical resolution of the DEM.

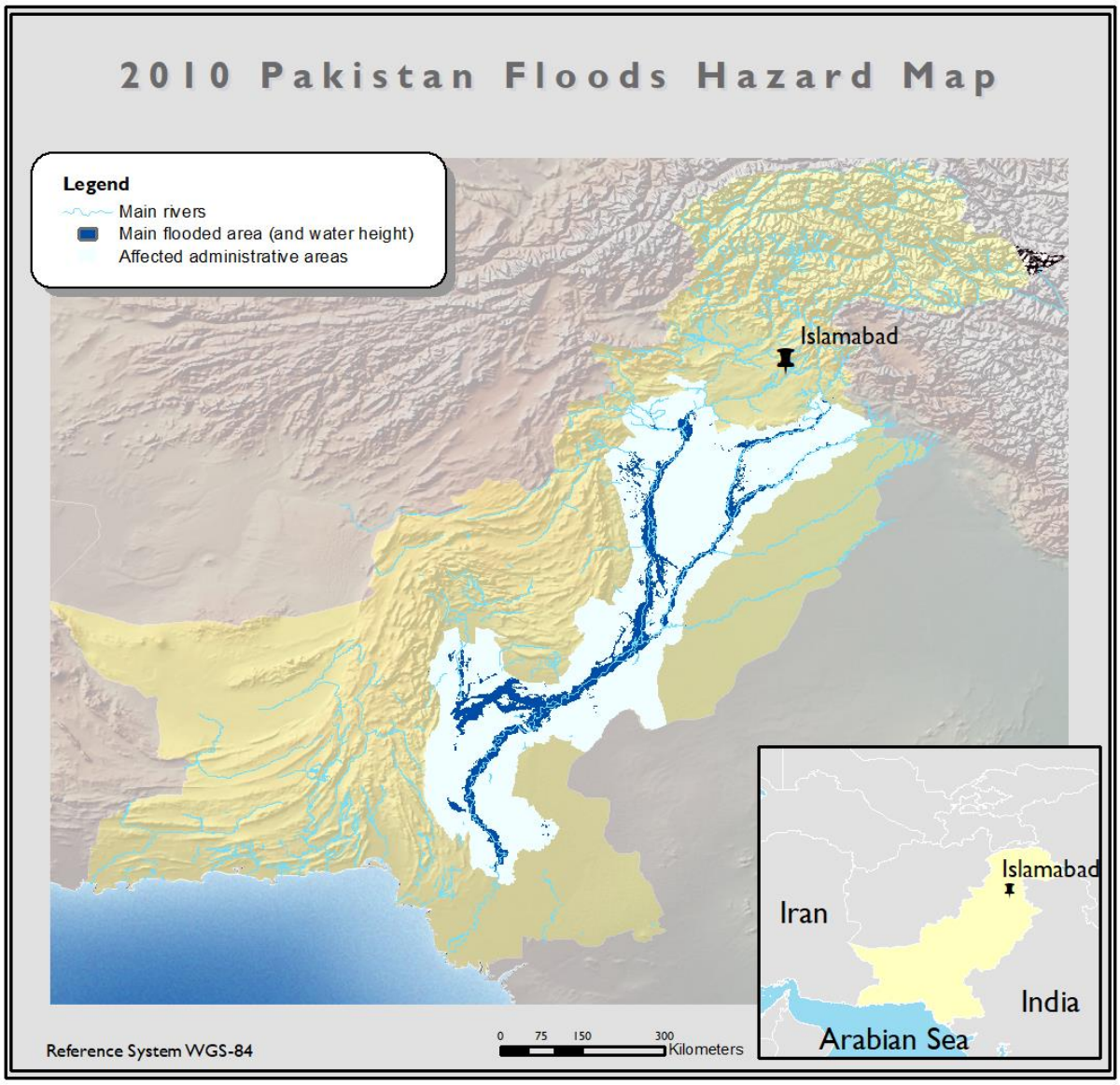

Figure 1: An overview of the 2010 Pakistan floods showing the main rivers, main flooded area and the respective water heights.

The assessment of the Pakistan residential buildings exposure was developed for the analysis of the July-September 2010 floods and the October 2005 earthquake in Pakistan. The exposure was estimated using the 2012 LandScan population layer. The residential exposure is at the district level. The last Population and Housing Census in Pakistan took place in March 1998 (a new census was carried out in 2017). A custom shape file of 123 Pakistan districts was developed as many districts were either split or merged in the last 20 years. The data of the 2014-15 Pakistan Social & Living Standards Measurement Survey (PSLM) were used to characterize the housing stock by its outer wall type (PSLM is a 1 per 300 household living conditions survey). This survey covers 100 districts i.e. it

includes most of the districts in the 5 non-autonomous provinces (ca 93% of the Pakistan population). Appropriate queries were developed in order to extract the necessary data. For the remaining districts the 1998 census data as shown in Appendix I of the University of Karachi report entitled "WP4-Seismic Vulnerability Assessment of Existing Buildings of Pakistan" were used with appropriate projections both in terms of numbers and typologies. The key indicator of people per dwelling unit (irrespective of wall type) was derived from the PSLM survey for each district as well as our own analysis for the 20 districts not included in the PSLM survey. The number of dwellings in 2012 was estimated at 31 million units, with average occupancy being 6.12 persons as opposed to 6.71 in 1998. This includes owner occupied as well as rented, vacant dwelling unitsFor dwelling size we used the PSLM survey (we obtained number of rooms and outer wall type cross tables) allowing for 25 square meters per room. The average dwelling size in Pakistan was thus considered to be 59.6 square meters. For the unit cost of construction we referred to the numerous Pakistan specific reports in World Housing Encyclopedia and well as to the Earthquake Reconstruction and Rehabilitation Authority reports. We have allowed higher unit costs in the 8 major cities of Pakistan (7 cities with 1998 population greater than 1 million and Islamabad). The exposure is adjusted to the Gross Capital Stock of Pakistan allowing for devaluation of older buildings. The Pakistan residential exposure sums to 169039 million USD (Fig. 2). In Fig. 3 the district-level per capita residential exposure is shown. It ranges between 133 and 2005 USD as it is influenced by the house typologies, dwelling sizes and the mean size of the households in each district.

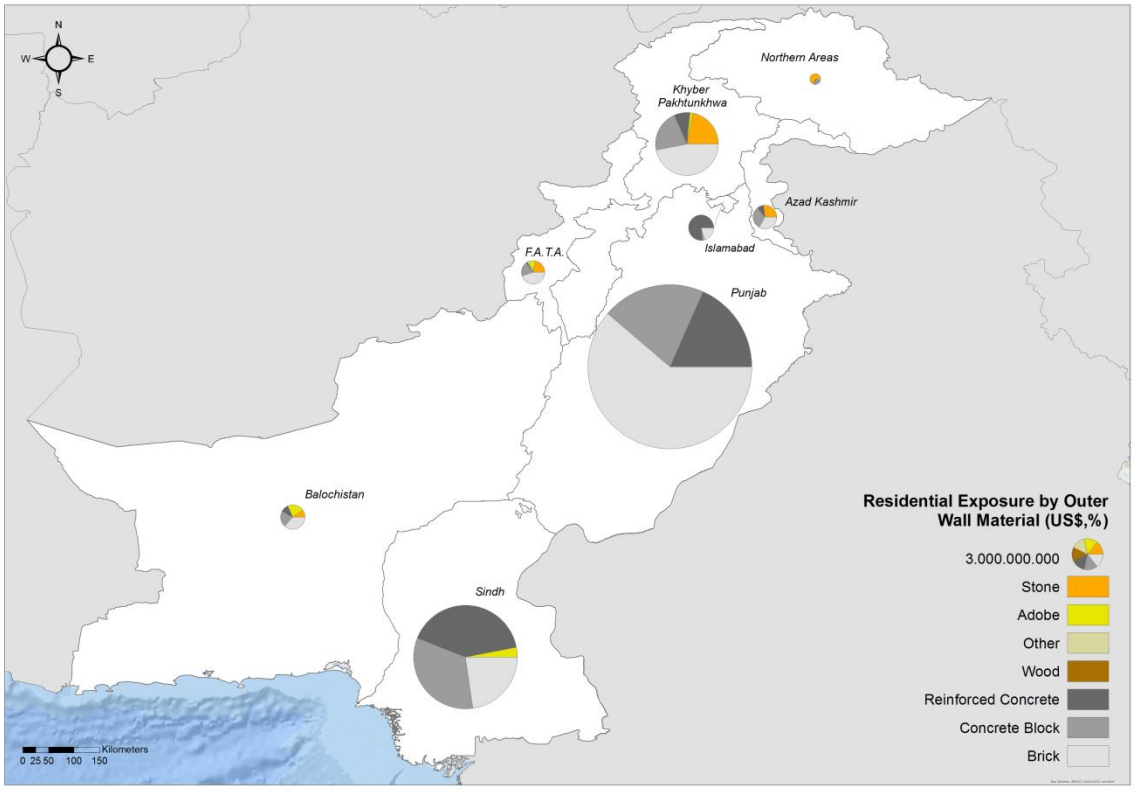

Figure 2: Residential exposure in Pakistan. The map shows the size of the exposure in USD (scaled pie charts) and its breakdown into outer wall typologies for each of the 8 provinces.

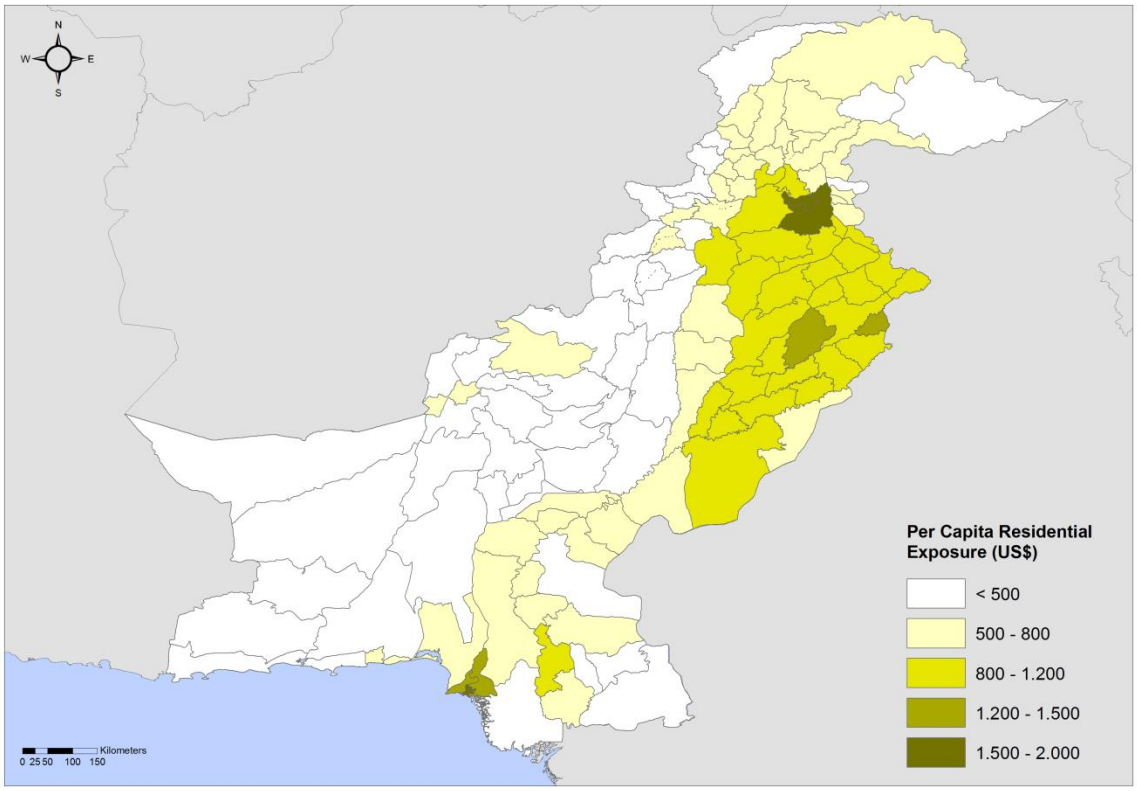

Figure 3: Per capita residential exposure in Pakistan (in USD) at district level.

Changing population in the flood zone

In the 2010 Pakistan flood footprint there has been a significant increase in population (88.5%) compared to the national population growth (36.7%) over the same time. This was estimated using the 2000 and 2015 population from the GHSL dataset of the JRC.

It can be suggested that this increase will likely exacerbate the flood losses, and we can expect that the greater exposure in the flood zone has led to the increase from 2010 to 2015 seen below.

Furthermore in 2015 nearly 8.8% of the country's population (16.6 million) lived within the flooded areas plus a 1-km buffer zone around them, showing the need for proximity to water for these locations yet the immense flood risk.

Flood vulnerability of building stock

On the basis of Huizinga et al. (2017), the derivation of generic flood curves for Pakistan building vulnerability were created. These functions have been derived based on historical events data and experience with respect to the various voids and typologies. The vulnerability functions relate the damage ratio to the water height.

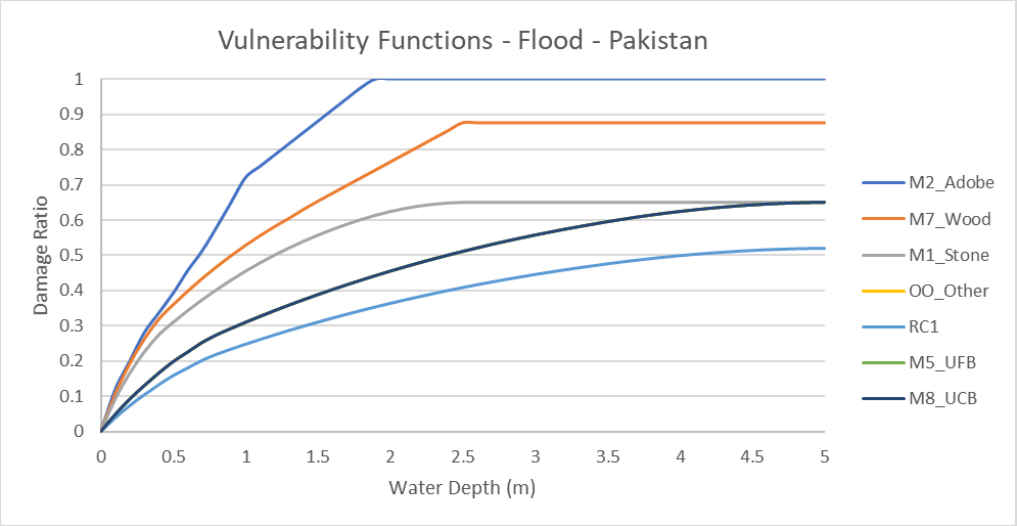

Figure 4: Vulnerability functions for flood in Pakistan

What are the potential losses due to the reanalysis?

	Historic	Modelled
Residential Damage (mn USD)	1513	2436
Residential Stock (mn USD)	119849	169039
Exposed to Flood waters (mn USD)		7966
Residential Loss Ratio	1.26%	1.44%

The residential damage was around 2.436 billion USD and is as expected located along the Indus river reaches. It is interesting to note that the residential loss ratio increased between the historic event loss and the modelled event loss, likely due to the exposure increase detailed above.

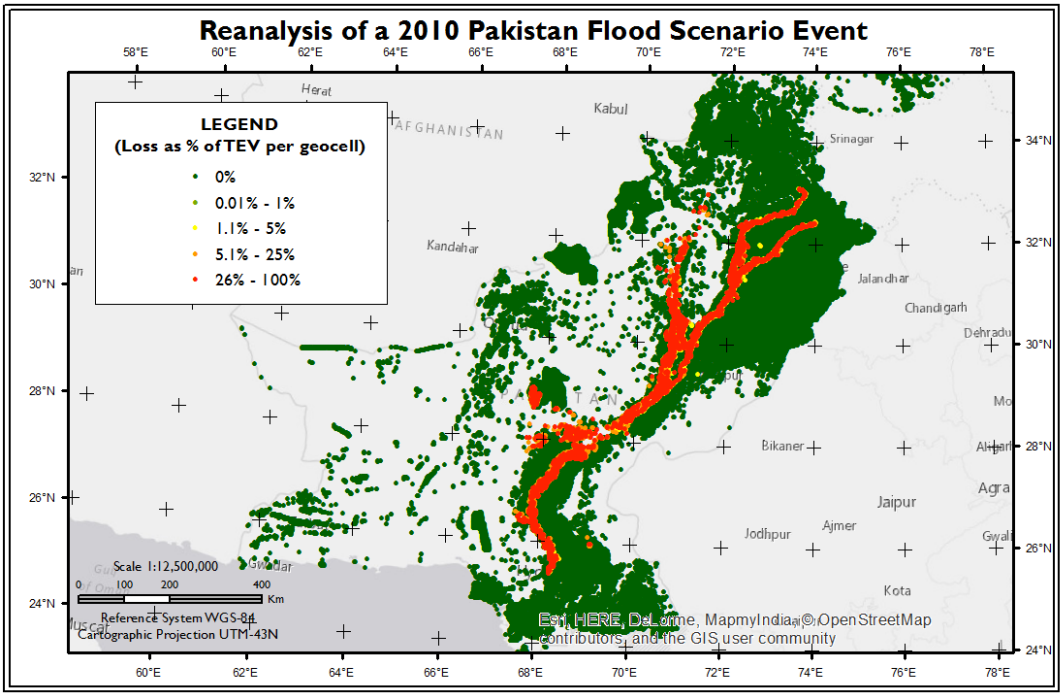

Figure 5: Relative losses at a 250m geocell resolution.

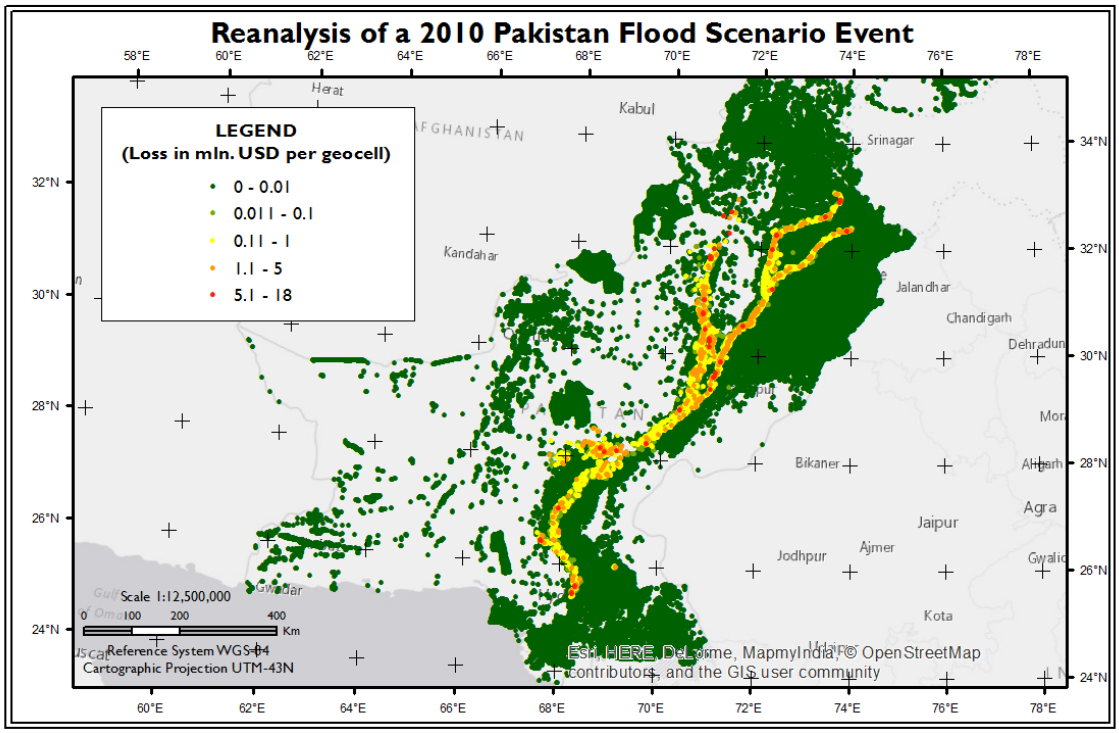

Figure 6: Absolute losses in million USD at a 250m geocell resolution.

As expected, those districts with most of their population along the river were most affected. The Top districts in absolute terms are shown below. Due to the distribution of population across a district and the greater percentage of pucca buildings, loss ratios are around 15% of a district at the most.

District	Province	Population (ppl)	Exposed Stock ($USD mn)	Loss ($USD mn)	Loss Ratio (%)
Muzaffargarh	Punjab	5027625	2752.3	387	14.06%
Jhang	Punjab	5664075	3361.9	316.3	9.41%
Khushab	Punjab	1808072	1167.8	186.6	15.98%
Multan	Punjab	5873254	4951.5	177.9	3.59%
Dera Ghazi Khan	Punjab	3020592	1050.8	153.8	14.64%
Layyah	Punjab	2394721	1196.5	150.3	12.56%
Dadu	Sindh	2924873	1777.5	149.9	8.43%
Jacobabad	Sindh	2303375	1230.7	139.8	11.36%
Rajanpur	Punjab	2204257	702.8	106.8	15.20%
Jhelum	Punjab	1776309	1430.9	86.2	6.02%
Dera Ismail Khan	FATA	1808100	517.1	56.8	10.98%

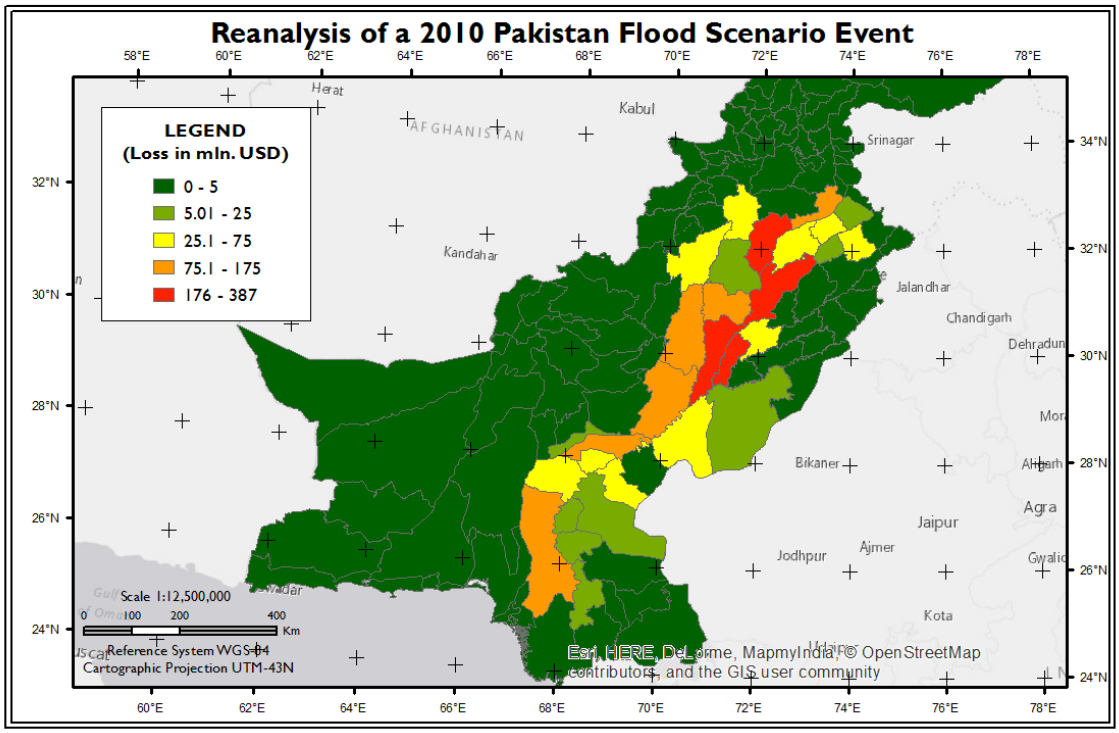

Figure 7: Absolute losses on an administrative level 2 unit (districts) (Loss as a % of Total Exposed Value)

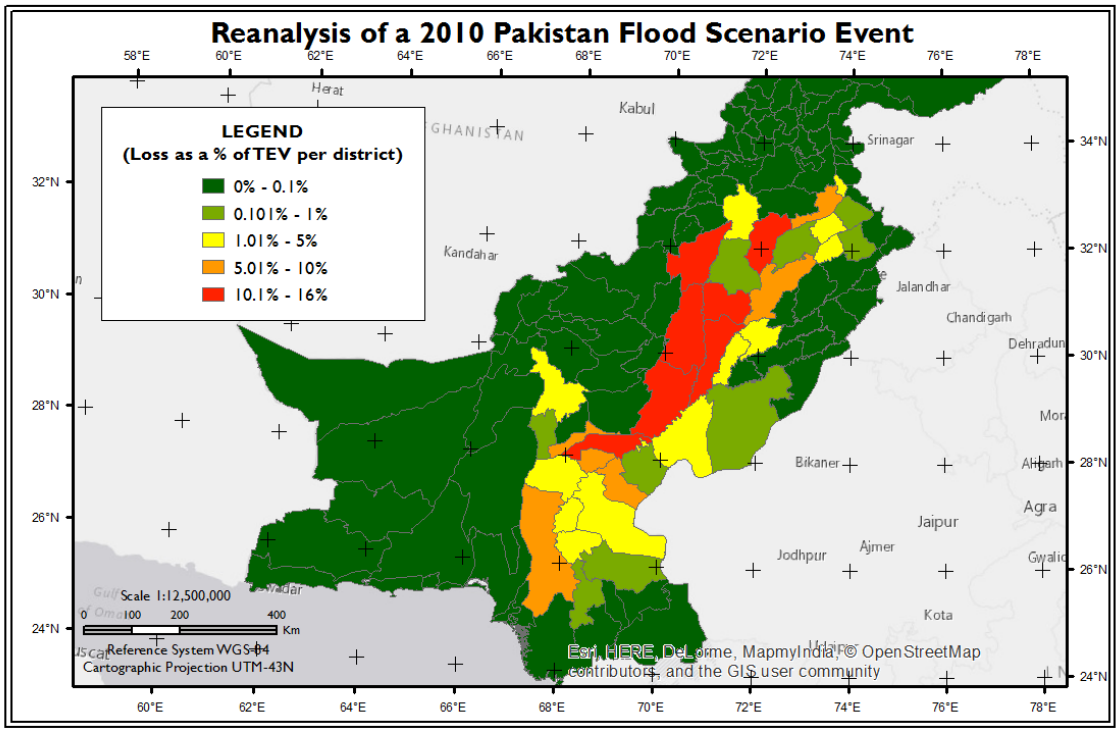

Figure 8: Relative losses on an administrative level 2 unit (districts) (Loss as a % of Total Exposure Value)

What is the return period of such an event?

Using GAR2015, the return period of an event loss is in the order of 40 years, after refactoring residential portions of loss, for the EP curve.

On the basis of historical events, the 1955-59 flood events, and the 1973-78 flood events caused major losses, and thus it would be suggested that a return period in the order of 30-40 years is reasonable.

Why was it important to collate the data?

The 2010 flood event was an extremely large event for Pakistan and the changing exposure has meant that it was necessary to examine the exposed stock for current conditions.