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ANALYTICS

Natural Catastrophe Risk Analysis in Pakistan

Pakistan Insurance Institute (PII) Conference

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12th April 2012

Overview

1. Need for quantifying natural catastrophe perils

2. Natural catastrophe perils in Pakistan
   1. Perils considered
      - Earthquakes, windstorms, floods
   2. Modelling natural catastrophe losses in Pakistan

3. Implications for National Natural Catastrophe Pools

4. Willis Research Network

Need for quantifying natural catastrophe perils

- Catastrophic events caused due to earthquakes, hurricanes, tornadoes and floods can jeopardise the financial stability of companies and national governments.

- To manage this risk, financial instruments that extend to natural catastrophe pools are employed.

- Key questions with respect to management of catastrophe risk are:

  - Where is my risk located?

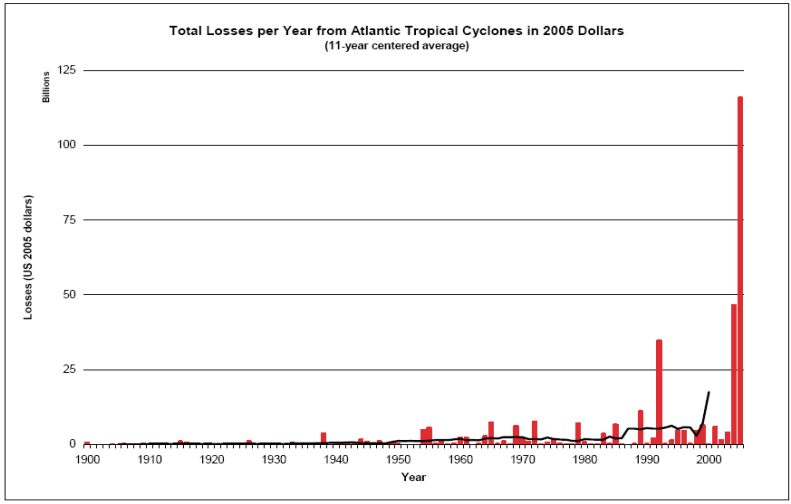
  - What is the expected Average Annual Loss?
    This concerns premium rate as charging an appropriate rate enables a company to operate smoothly and with stability while making reasonable profits for share holders.

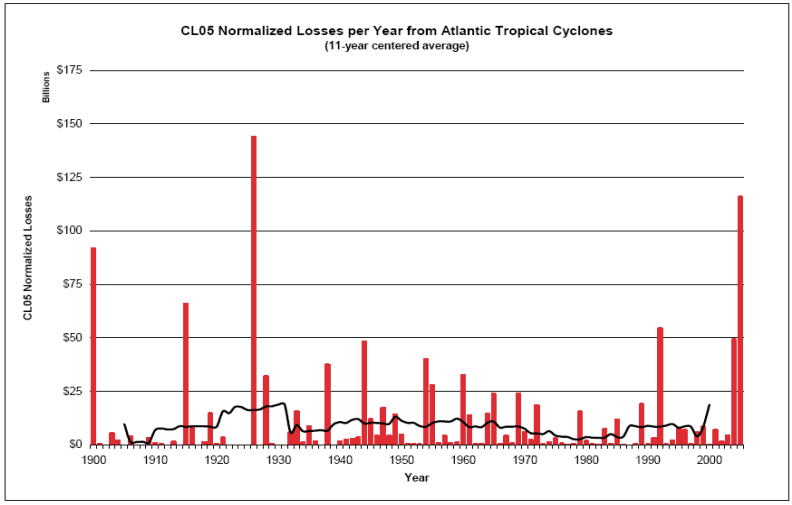
  - What is my Probable Maximum Loss within a [250] year return period?

  - How can my portfolio be optimised?

Problem with experience based pricing

- Population growth
- Growth in property values
- Growth of urban concentrations
- Settlement and development in exposed regions
- Rise in standard of living
- Increased international trade - marine cargo exposure
- Increased insurance penetration
- Political pressure for government compensation
- Increase in losses not necessarily linked to increase in hazard





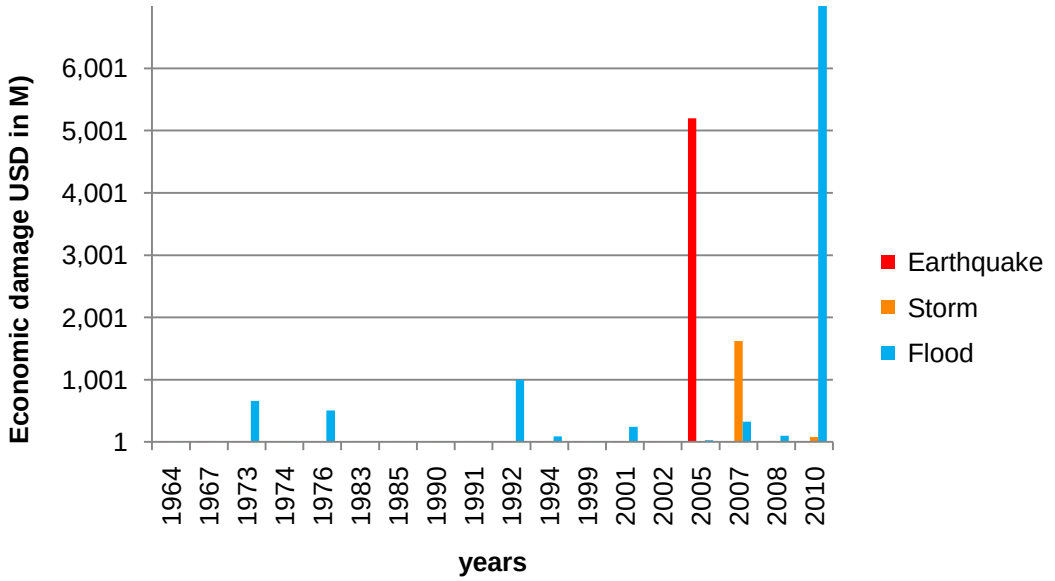
Source: Normalized Hurricane Damages in the United States: 1900-2005 Pielke et al Natural Hazards Review

Natural Catastrophe Perils in Pakistan

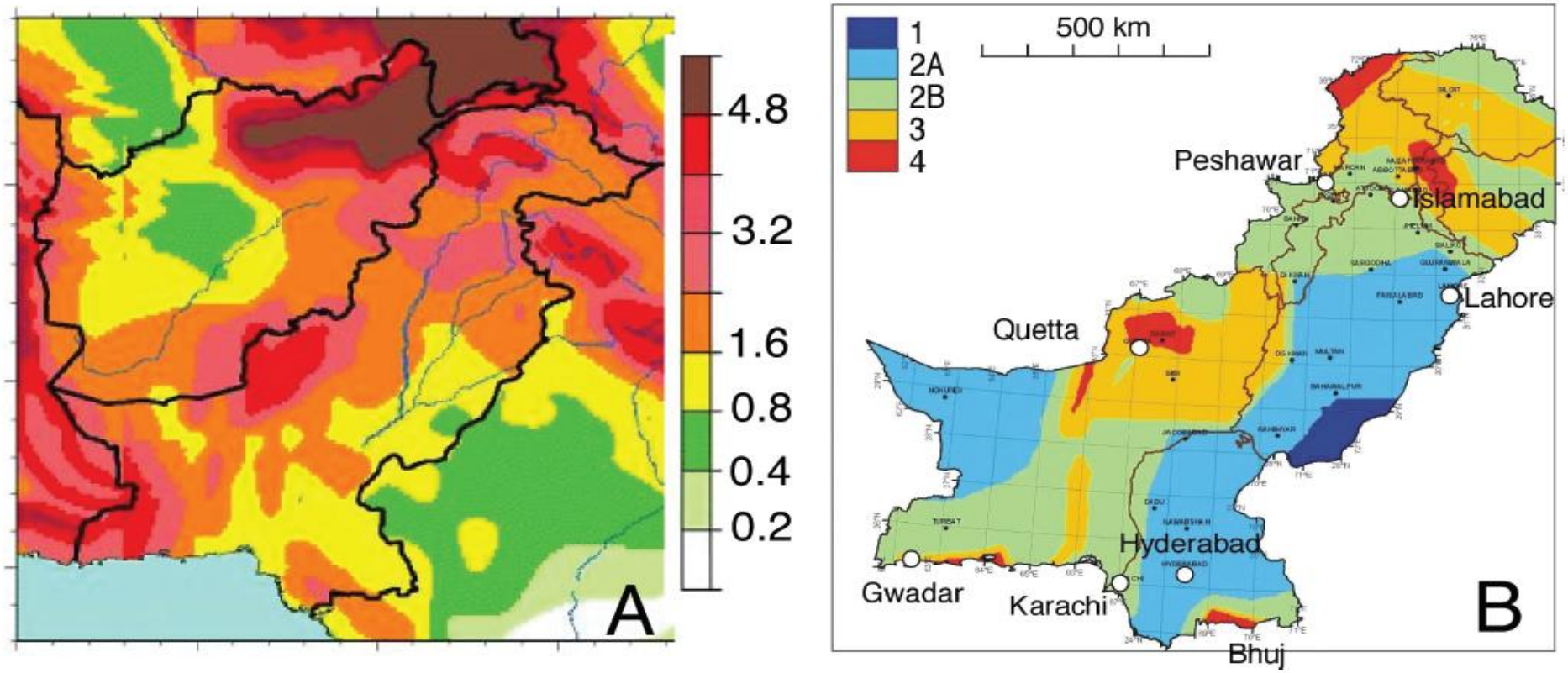
	Level of Risk
Earthquake	Moderate-high
Windstorm	Moderate
Flood	High
Landslides	High
Tsunami	Moderate

Period	Earthquake	Flood	Windstorm
1930s	60,000	-	-
1940s	4,000	-	-
1950s	-	3,691	-
1960s	-	32	10,450
1970s	4,700	2,066	-
1980s	289	519	121
1990s	413	4,180	956
2000s	73,576	2,265	369
2010s	2	2,569	23

Empirical cat peril risk perspective (Top left),
Loss data: Casualties (bottom Left) and economic damage (bottom right) Source: EM-DAT.



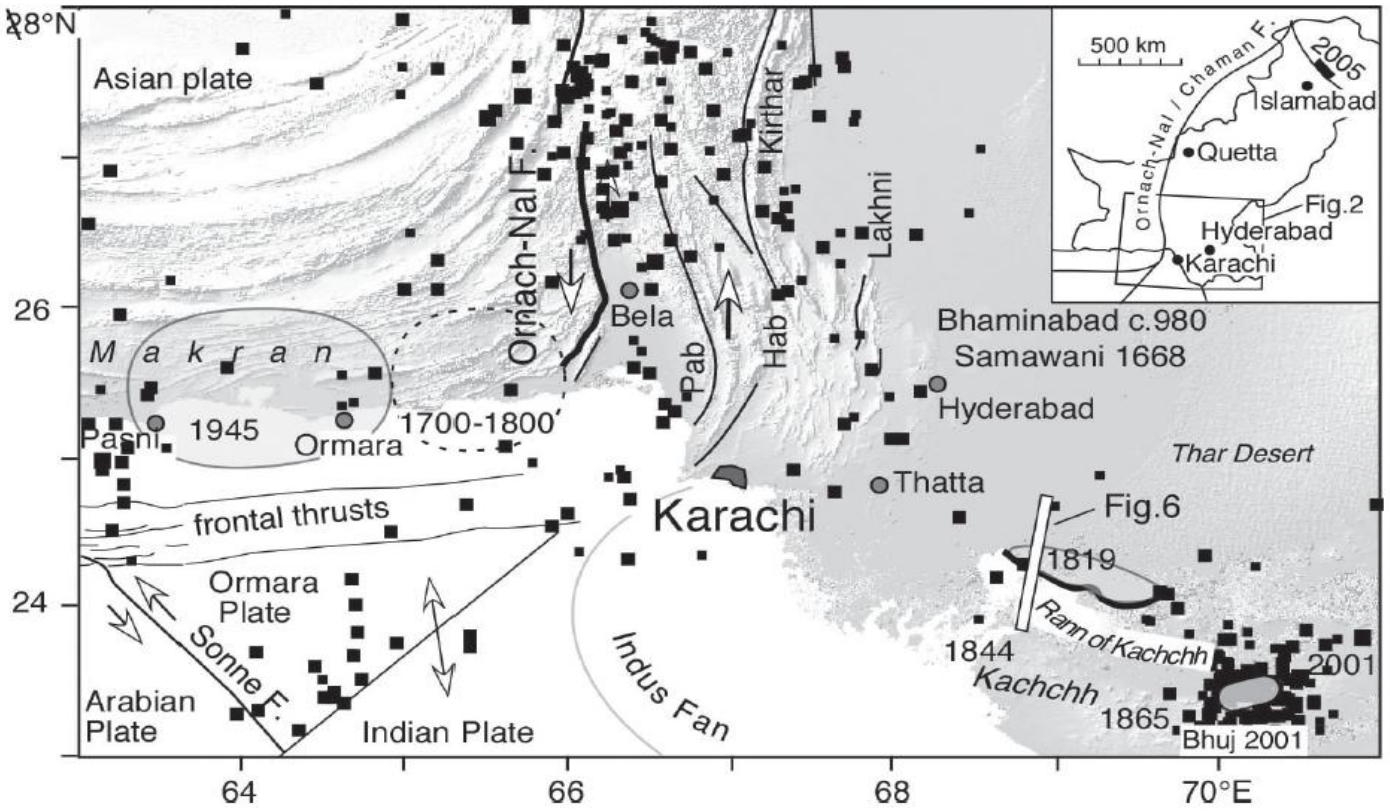
Seismic hazard in Pakistan



▲ **Figure 7.** (A) GSHAP hazard map of Pakistan (Giardini *et al.* 1999; color scale indicates peak ground acceleration (m/s/s) with 10% probability of exceedance in 50 years) compared to (B) a recently revised hazard map following the 2005 earthquake (working group on Pakistan Hazard 2006; zonation 4 is most hazardous, 1 is least hazardous).

Source: Bilham et al. (2007) - Seismological Research Letters

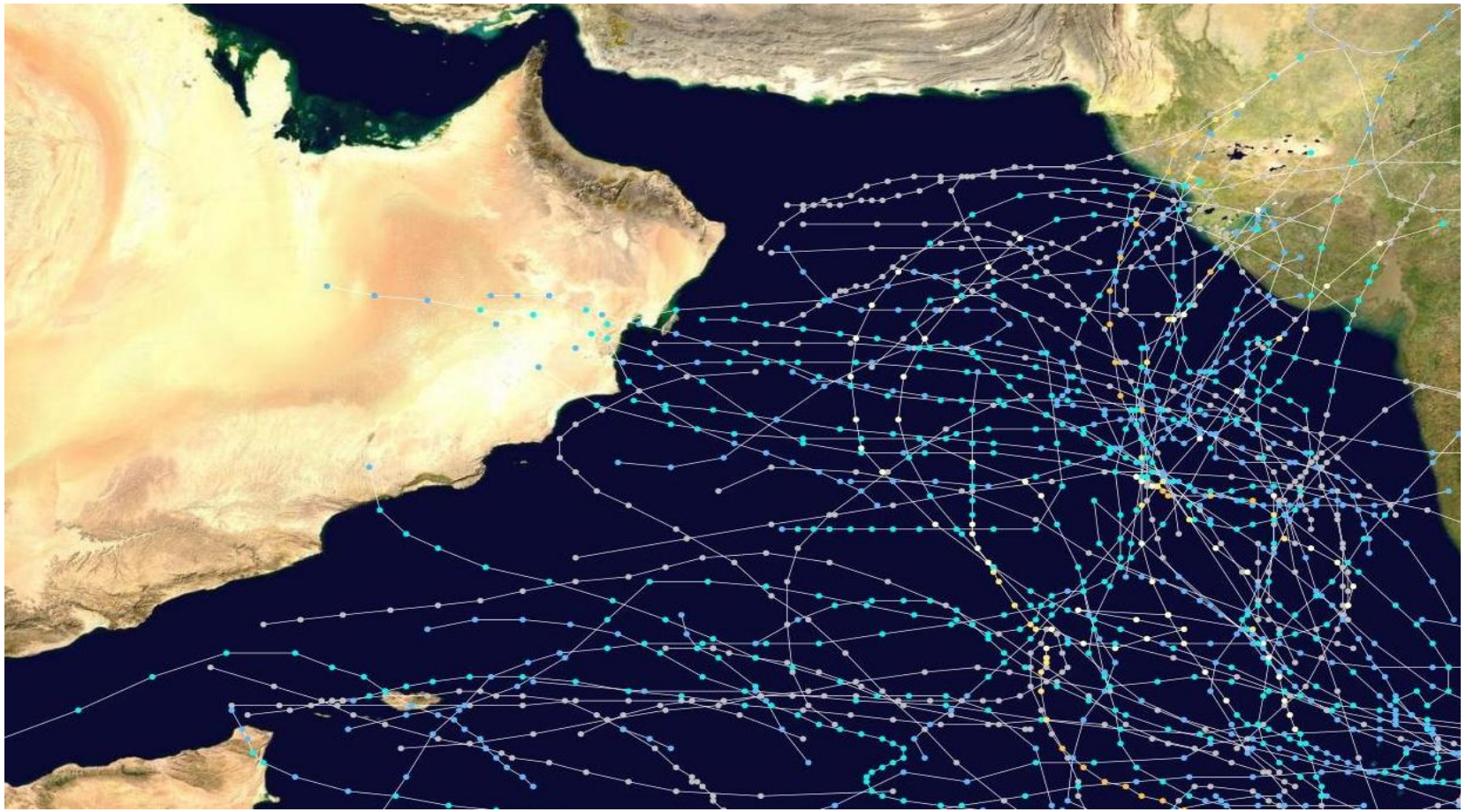
Seismic hazard in Pakistan



▲ **Figure 2.** Locations of active faults and dated historical earthquakes with inferred ruptures outlined. Locations of moderate events shown only by date; smaller shocks (3.8 < **M** < 5.5) as squares proportional to magnitude. The Sonne fault offsets ridges in the accretionary wedge at 2–5 mm/yr (Kukowski *et al.* 2000). No large earthquake is known historically on the Ornach Nal system. The dashed oval is the inferred 1765 event depicted by Byrne *et al.* (1992); we show its date and size and location to be conjectural. Although the 1819 earthquake was apparently similar or larger in magnitude than the 2001 Bhuj event, little damage occurred in Thatta and Hyderabad in 1819 compared to 2001 even though the former event was closer.

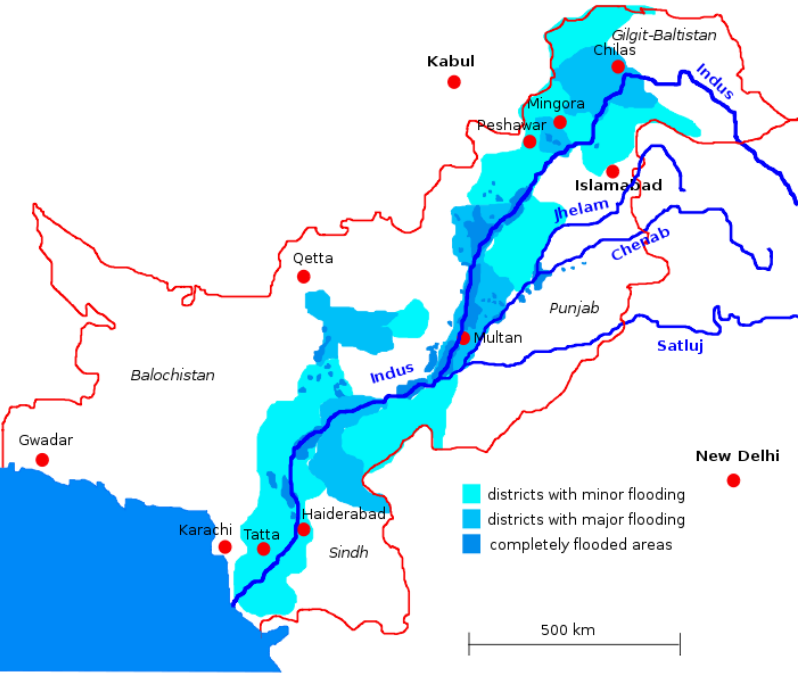
Source: Bilham et al. (2007) - Seismological Research Letters

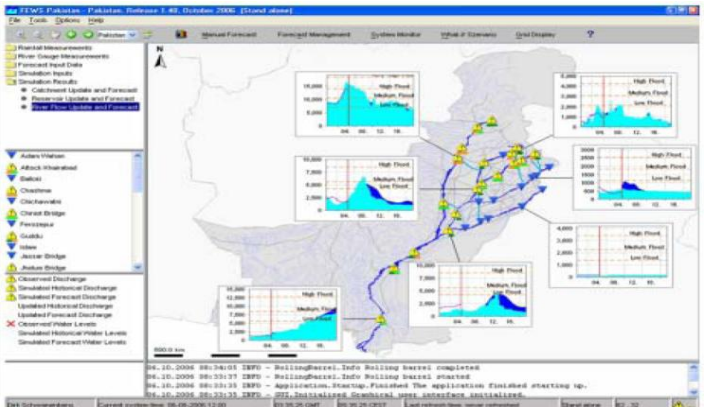
Windstorm hazard in Pakistan



Tropical cyclone tracks from 1970 to 2005

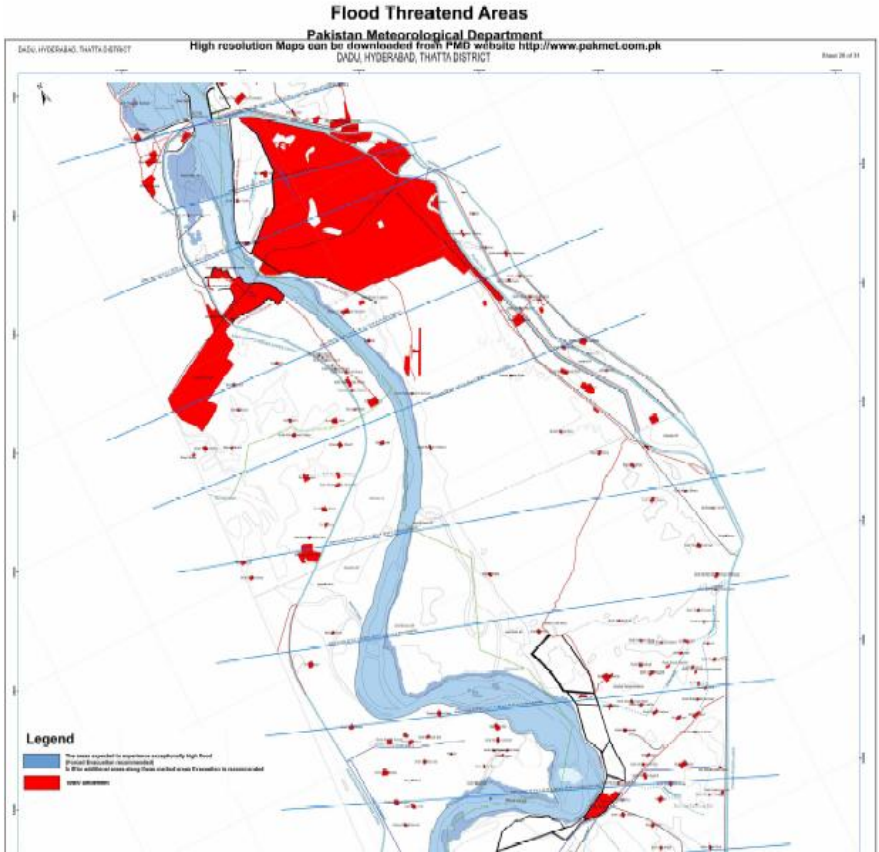
Flood Hazard in Pakistan



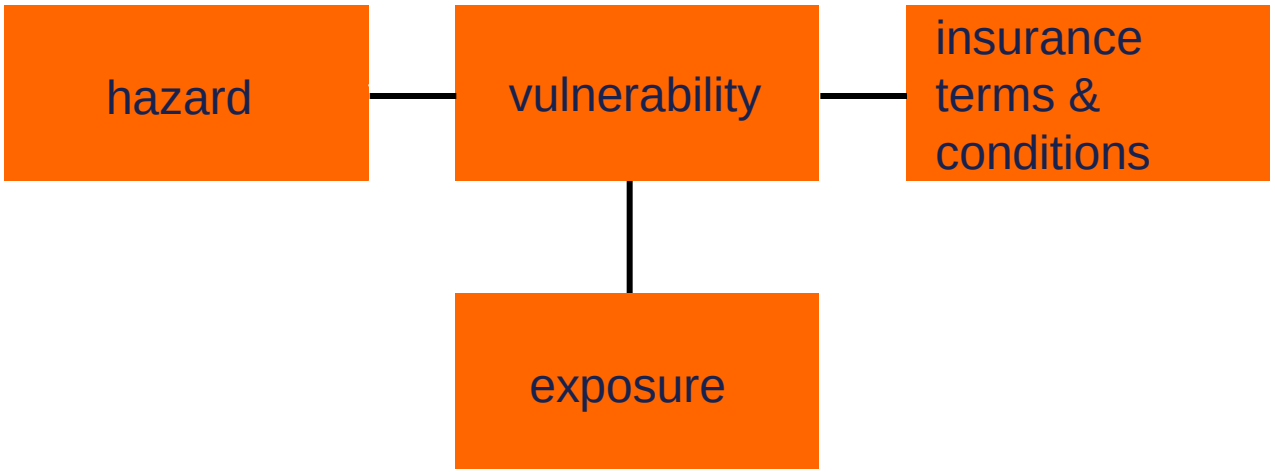


Flooded areas in 2010 (left). Information available on discharge rates (bottom left) and flood prone regions in Dadu, Hyderabad and Tatta districts (bottom right).

Source:: http://www.pmd.gov.pk/ http://en.wikipedia.org/wiki/2010_Pakistan_floods



Modelling natural catastrophes in Pakistan



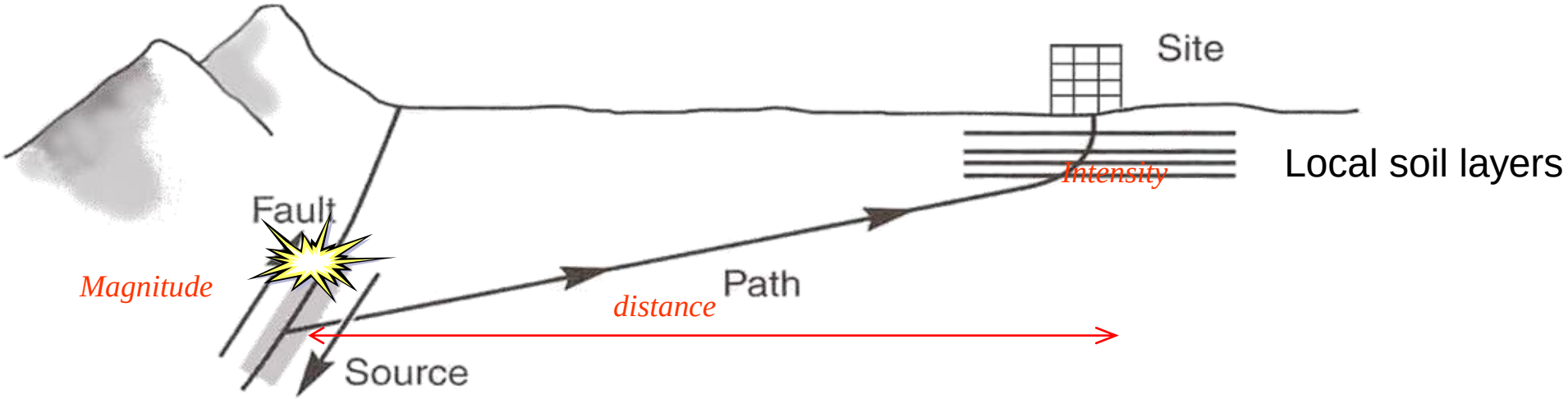
= insured risk

Hazard
- earthquake sources – defining event epicentres
- seismicity model – magnitude, frequency of the event
- attenuation model – local site amplification

Vulnerability
- structural response to ground motion
- damage / loss validation

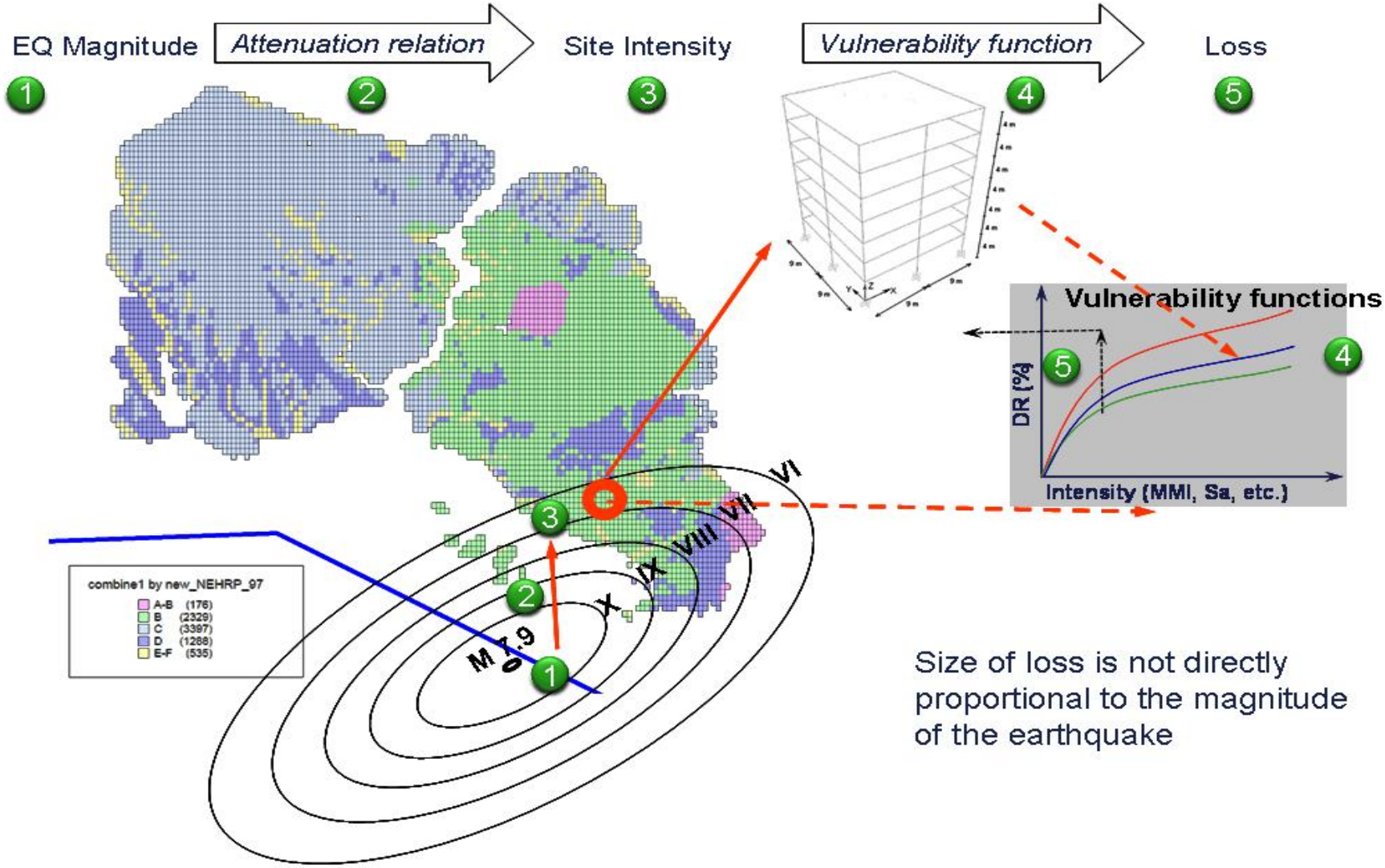
Exposure
- building construction and occupancy type and additional structural modifiers (e.g. year built, number of storeys, construction quality)
- locational information
- value at risk estimation

Catastrophe loss estimation: Earthquake and its describing parameters



- Released energy of the Earthquake in the source is represented by *Magnitude*
- Severity of ground motion in a site at a certain distance from source is indicated by *Intensity* (*spectral parameters, etc.*) based on the magnitude and *attenuation relation*
- Due to the intensity and based on the resistance of structures, they will undergo different grades of *damage*
- This damage will result in *loss* (financial or casualties)
- *Achieved through deterministic or probabilistic approaches*

How do you model an earthquake loss in Pakistan?



Size of loss is not directly proportional to the magnitude of the earthquake

Pakistan earthquake distribution

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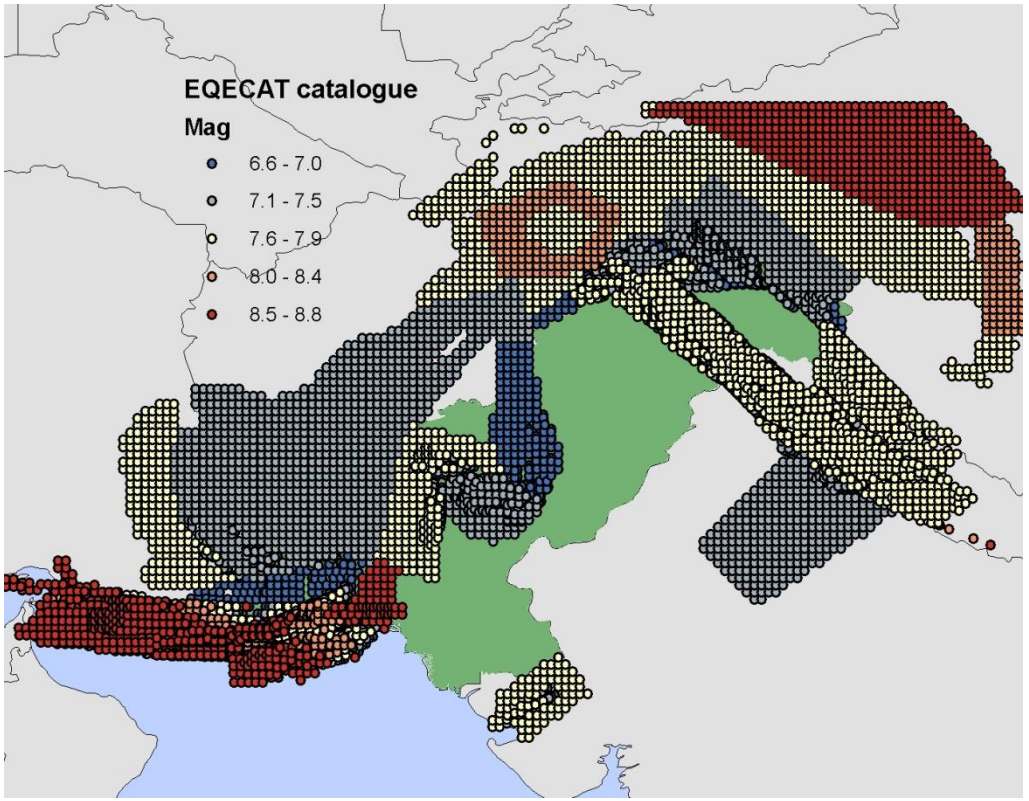
An event by event scenario was run for the Pakistan EQ model using large country-wide exposures. The resulting map shows that the probabilistic events follow a grid, with numerous events per latitude/longitude. The higher magnitude events are concentrated around northern and southern edges of Pakistan reflecting the regional seismicity.

(however the damage functions are specific to the Pakistan based on engineering judgement).



EQECAT model for Pakistan

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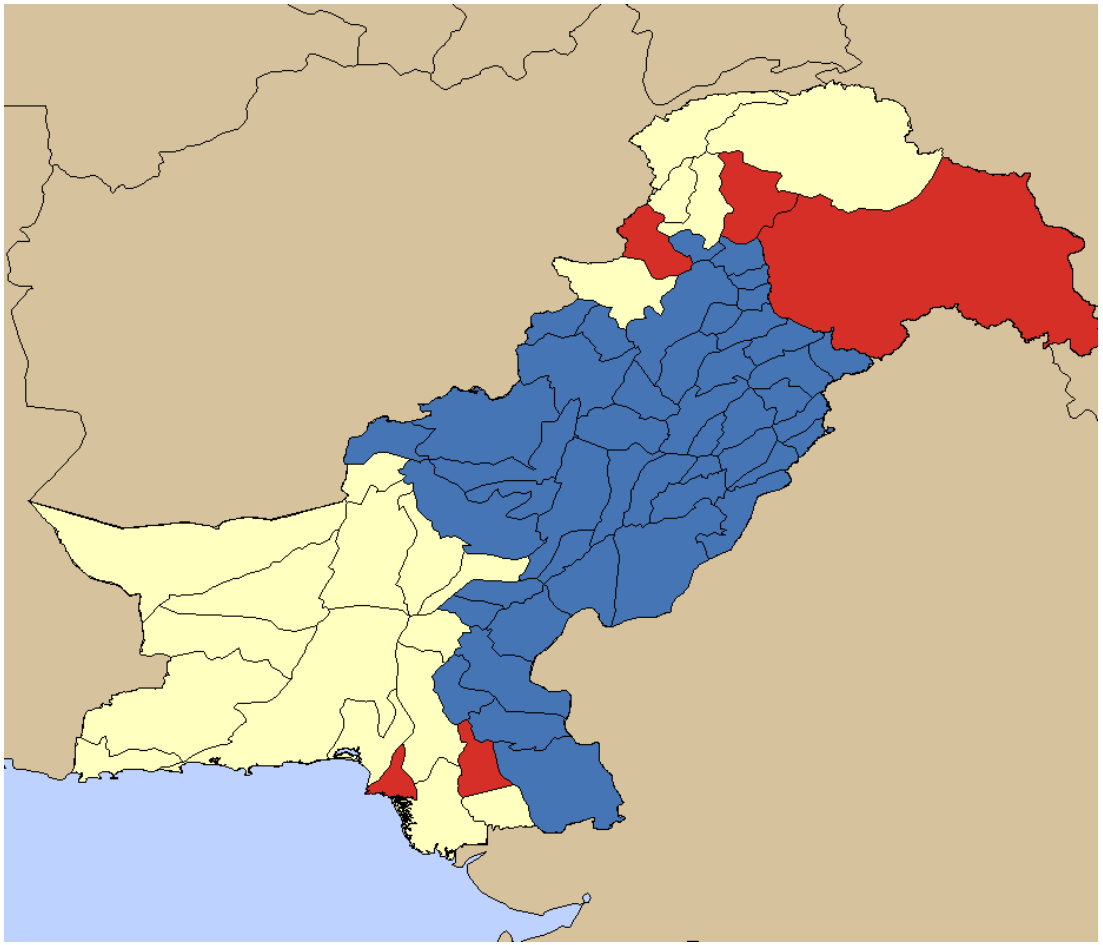
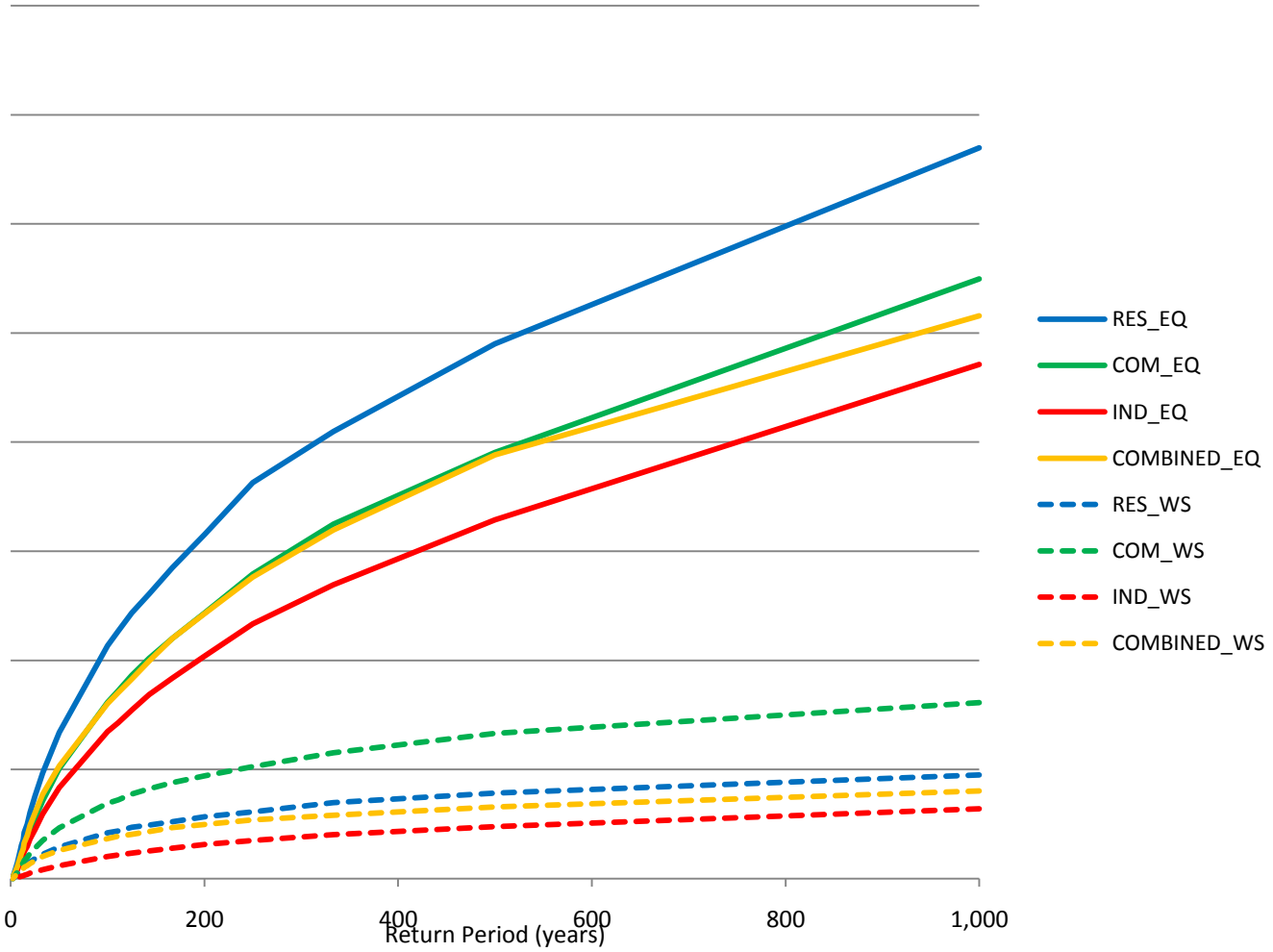
AAL by CRESTA distribution for Pakistan for a flat portfolio

Vintage	2009 (Earthquake); 2007 (Windstorm)
Methodology	WCC (WorldCat Classic)
Perils	Earthquake Shake; Windstorm
Hazard model resolution	Population centres
Event frequency distribution	Poisson
Event severity distribution	Normal
Vulnerability set	Standard Classic classification - The same standard set of vulnerabilities is used for all the aggregate WCC models.
How the vulnerabilities compare to those in other territories	Not documented
Seismic source model used	"Zoneless approach". The 'Kernel Estimation Method' (1996), relies on historical seismic event data for the calculation of seismic activity intensity rates over territories.
Intensity measure	MMI (Modified Mercali Intensity)
Event set	The Kernel Method uses background sources between M6.6 and 8.8.



Pakistan – MSA by Risk Type (EQECAT)

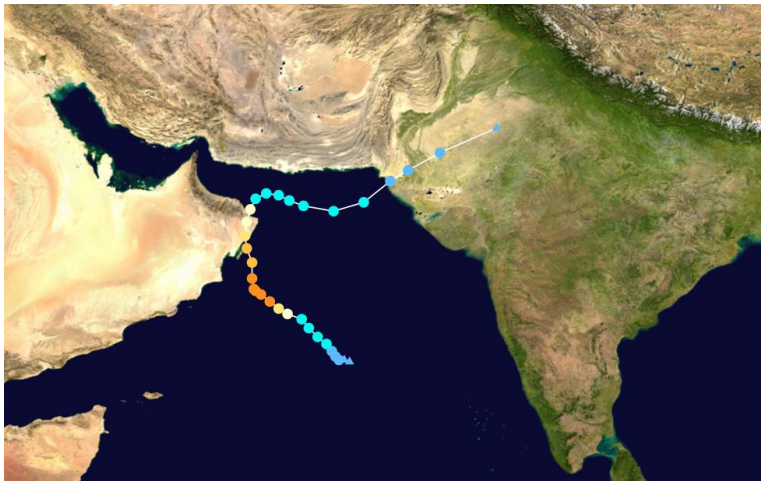
- **In order to test the validity and sensitivity of the EQECAT model, a number of benchmarking tests were undertaken.**
- **By varying one a parameter at a time, an idea of the relative vulnerabilities across the model can be ascertained.**
- **For consistency, an exposure of $1m USD per zone was modelled, and the sensitivity of risk type was examined.**

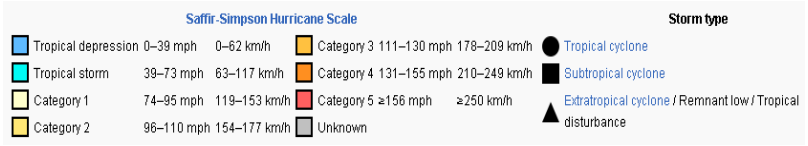


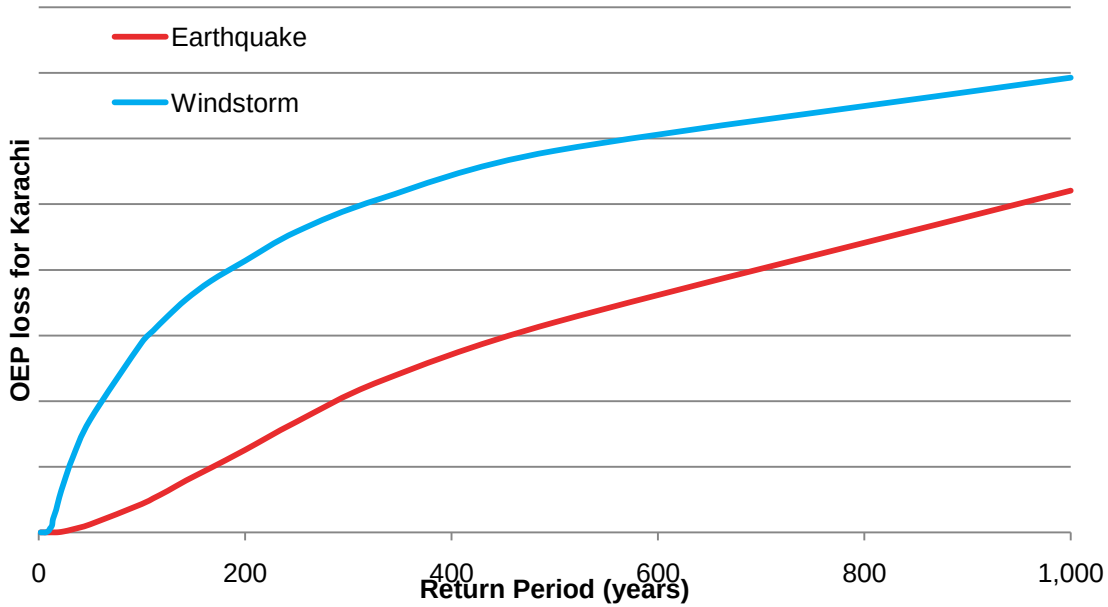
Karachi – Impact of different perils (EQECAT)

Cyclone Phet – June 2010

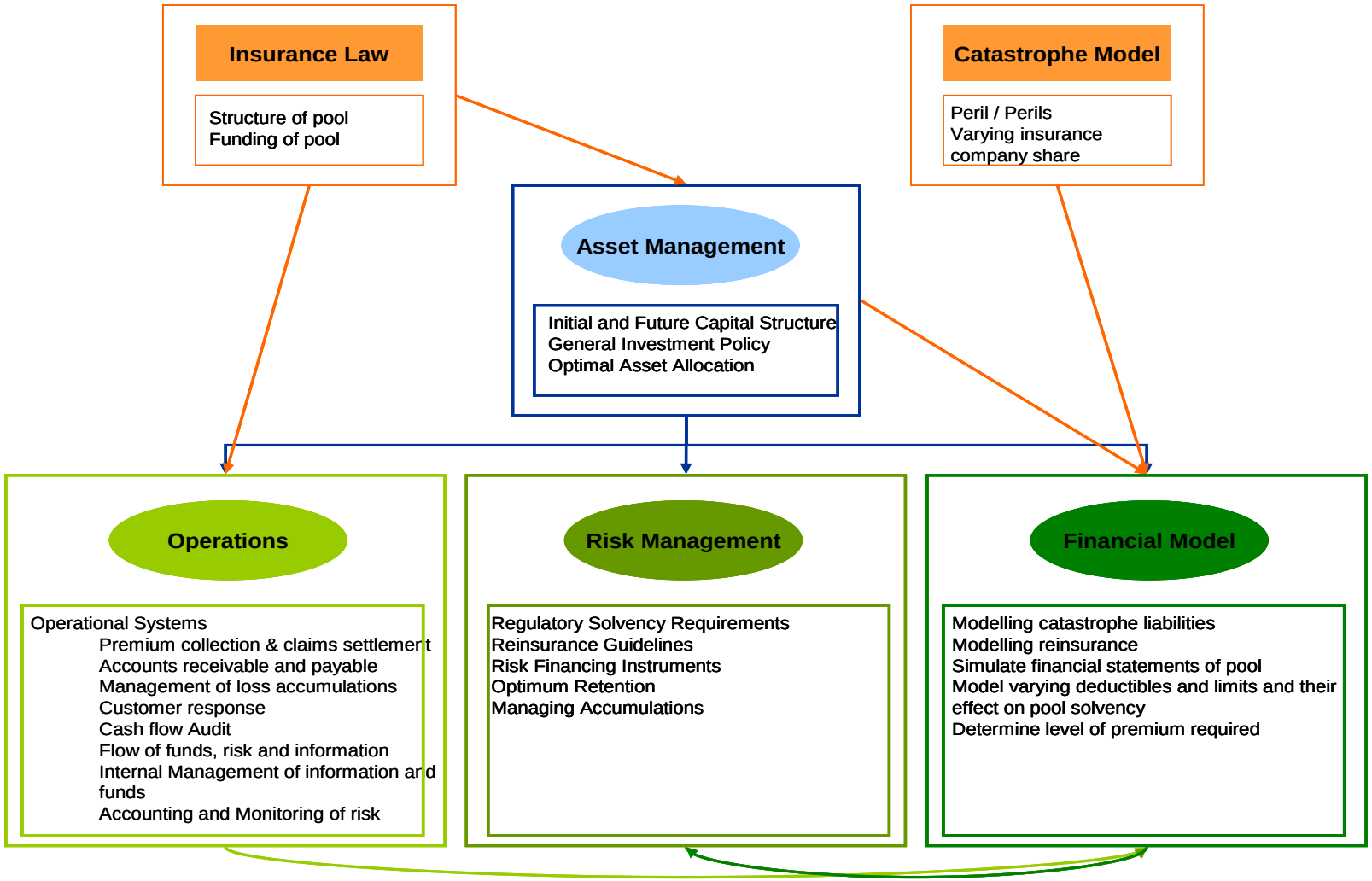
http://upload.wikimedia.org/wikipedia/commons/6/68/Phet_2010_track.png



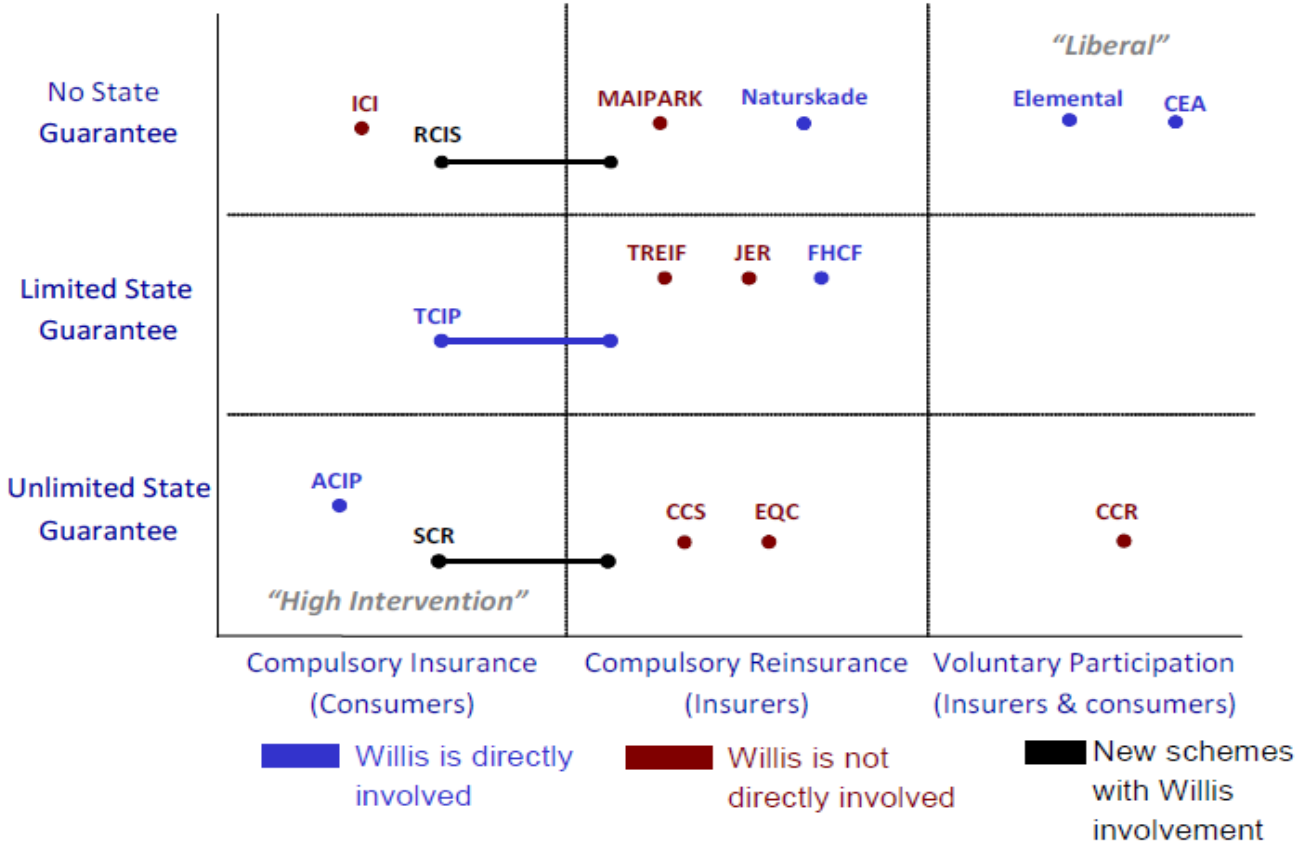




Implications for National Natural Catastrophe Pools



Willis' involvement in national schemes



ACIP	Algerian Catastrophe Insurance Pool (Algeria)
CCR	Caisse Centrale de Réassurance (France)
CCS	Consorcio de Compensación de Seguros (Spain)
CEA	California Earthquake Authority (USA)
Elemental	Elementarskadepool (Switzerland)
EQC	Earthquake Commission (New Zealand)
FHCF	Florida Hurricane Catastrophe Fund (USA)
ICI	Iceland Catastrophe Insurance (Iceland)
JER	Japan Earthquake Reinsurance Co (Japan)
MAIPARK	PT. Asuransi MAIPARK (Indonesia)
Naturskade	Norsk Naturskedepool (Norway)
RCIS	Romanian Catastrophe Insurance Scheme (Romania)
SCR	Société Centrale de Réassurance (Morocco)
TCIP	Turkish Catastrophe Insurance Pool (Turkey)
TREIF	Taiwan Residential Earthquake Fund (Taiwan)

Willis Research Network membership

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Key WRN research Themes

- **Flagship research projects:**

Hybrid loss model for seismic risks: Imperial College, ROSE School Pavia, Cambridge University, Kyoto University, Colorado University

Regional flood risk: Bologna University, Exeter University, Fluvius Consulting (Vienna), Bristol University, Durham University, Princeton University , Newcastle

Extreme weather hazard modelling from GCMs: Tropical Cyclone and hurricane

Walker Institute / Reading University, NCAR Colorado, National University Singapore, Systems Engineering Australia, University of Exeter

Public-policy catastrophe risk transfer optimisation:

Oxford University, Wharton, UPenn, ETH Zurich, Scripps

Overarching research projects:

Demand surge – led by Colorado University

Business interruption and infrastructural risk - led by Kyoto University

Risk and uncertainty visualisation – led by City University, UWI

Extreme statistics and uncertainty – led by Exeter University

Exposure, post event calibration and remote sensing – led by Cambridge University

Urban and megacity risk – all members

High performance computation – all members

Operational Risk, Cost of Capital and Public-private risk transfer – including ETH, Swansea, Wharton

Disclaimers

Willis Re Analytics gratefully acknowledges the kind permission of EQECAT to perform MSA for their Pakistan Earthquake and Windstorm models.

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