GIS TOOL FOR CALCULATING REPAIR COST OF BUILDINGS DUE TO EARTHQUAKE EFFECTS (CCRE - CISMID)

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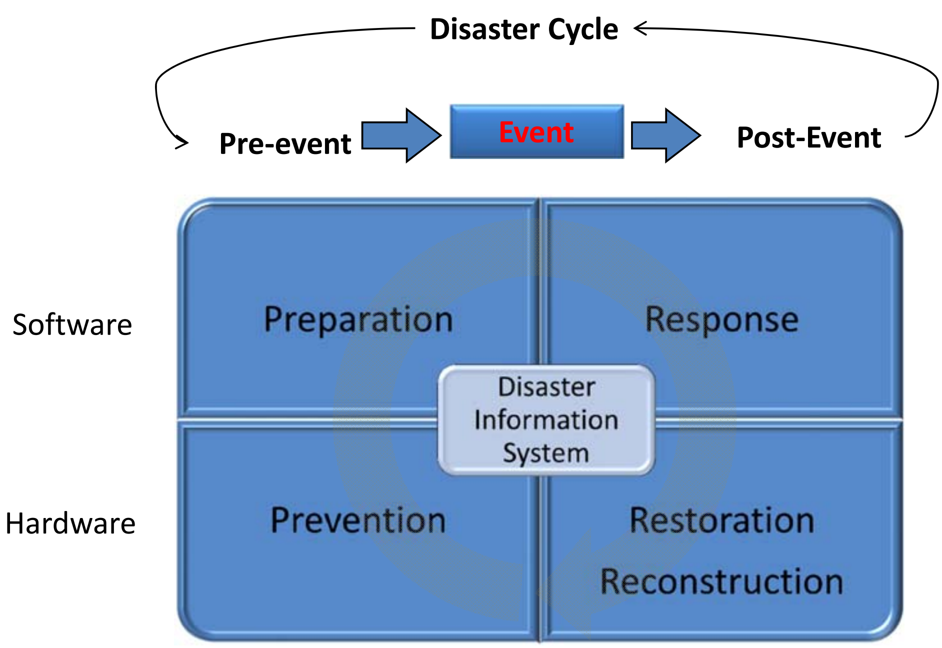
Disaster Management Cycle



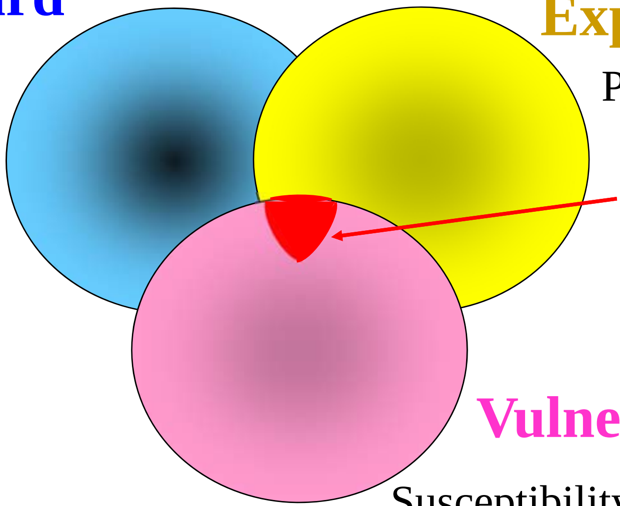
Risk Components

Hazard

Earthquakes,
Landslides,
Tsunamis

Exposition

People, Properties



Disaster Risk

Vulnerability

Susceptibility to natural hazards

Risk = Function (Hazard, ***Exposition, Vulnerability***)

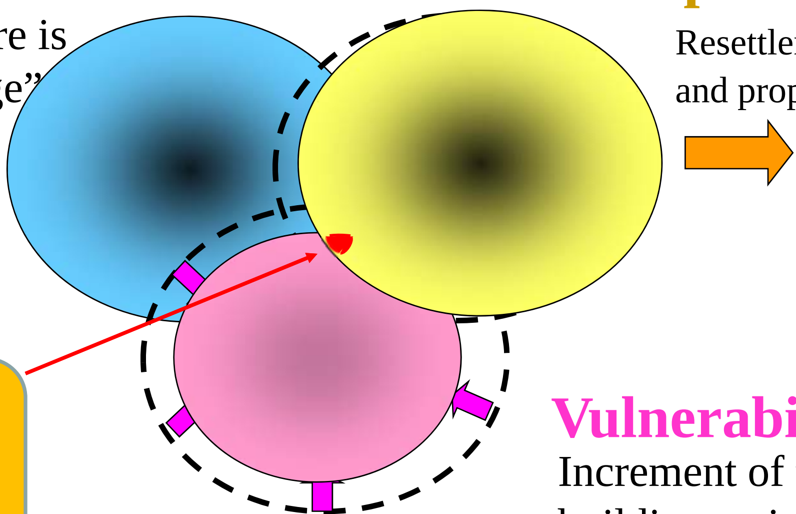
Risk Components ➡ Reduction

Hazard

Basically without changes but there is "Climate Change"

Exposition ⬇

Resettlement of people and properties

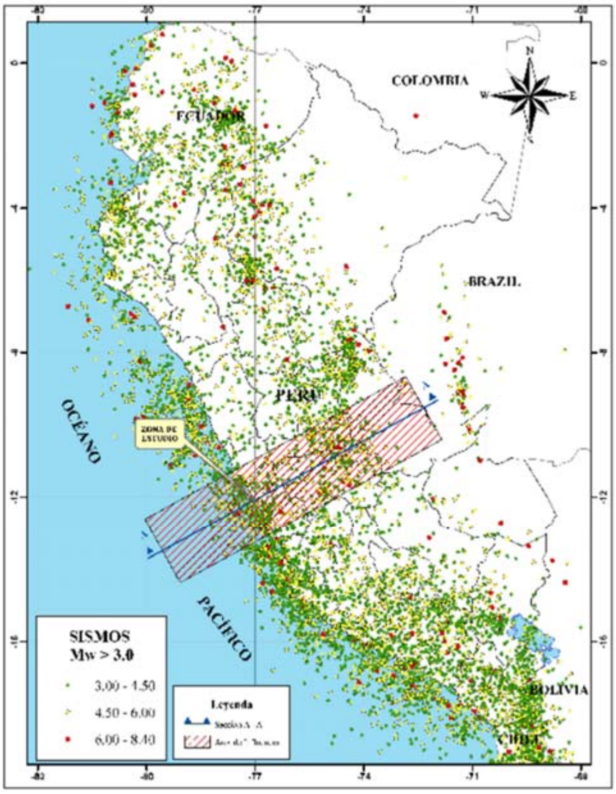


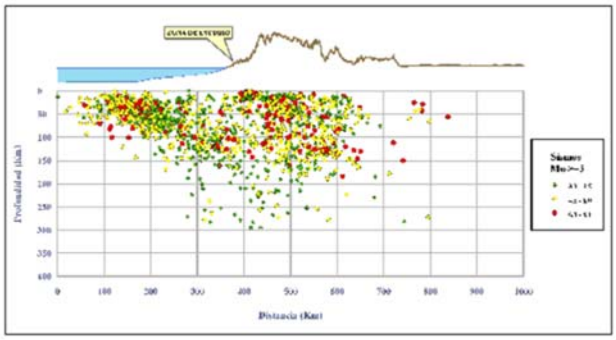
Risk disaster reduction

Vulnerability ⬇

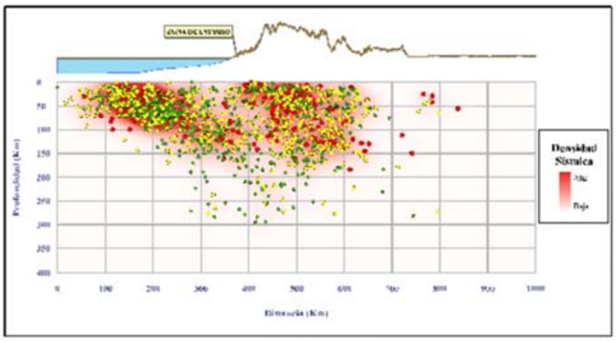
Increment of the building resistance

Seismic Hazard – Peruvian Seismicity





Sección A - A
Escala 1: 7,000



Densidad Sísmica Sección A - A
Escala 1: 7,000

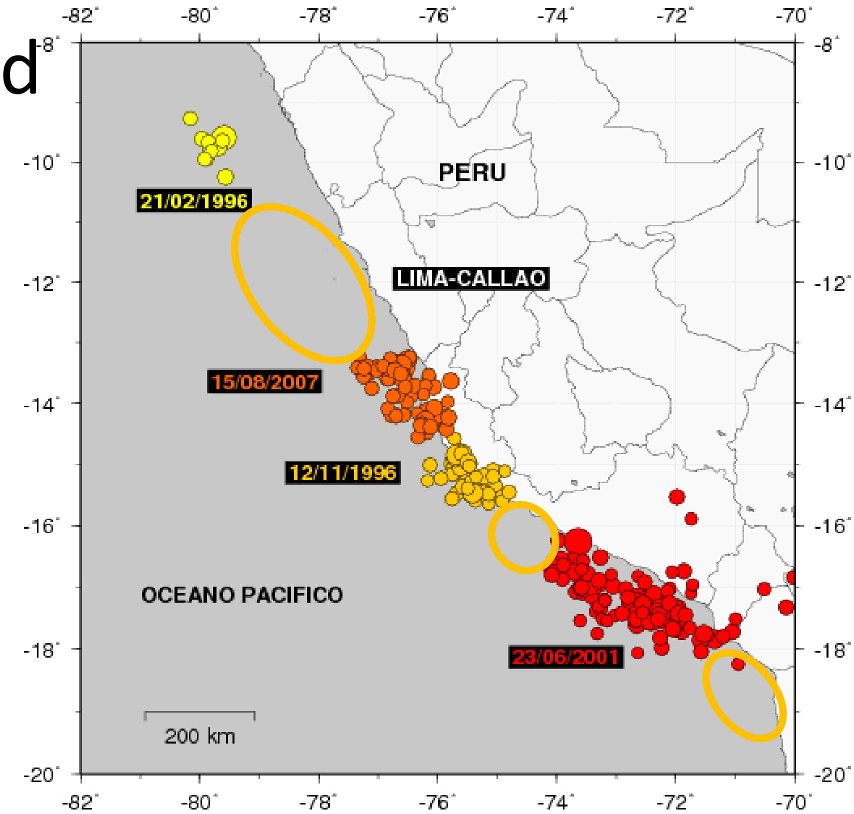
Seismic Hazard

Peruvian Coast

Earthquakes with Magnitude > 5 1973 - 2010

Seismic Hazard

Recent earthquake with magnitude greater than 7 and that produced tsunami



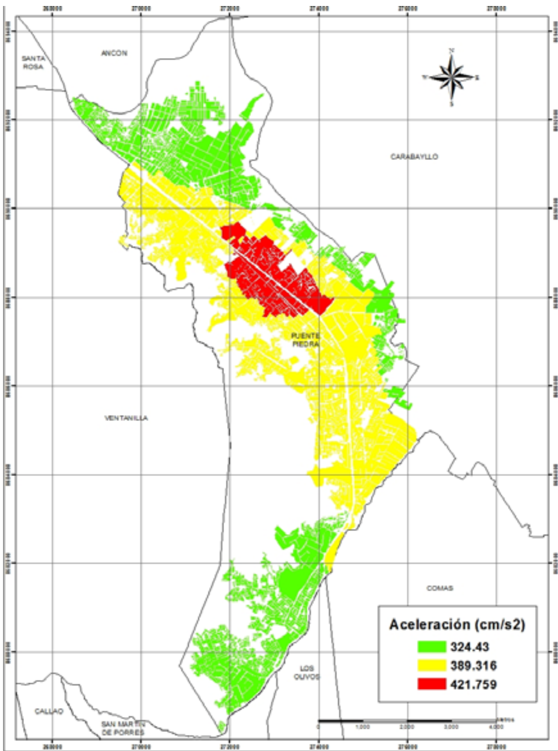
Focusing in Assess the Vulnerability

- All these reasons make the necessity to develop a practical tool to identify the vulnerable urban areas due to effects of a big earthquake. This tool is based in three aspects:
  - Seismicity of the area
  - Soil conditions
  - Structural characteristics of the buildings

Soil Conditions

- To determine the type of soil and its response in case of an earthquake some field survey are conducted:
  - Borehole exploration,
  - Shear wave measurements,
  - Microtremor measurements,
  - A geotechnical map is developed, and
  - Acceleration map for an earthquake scenario is developed.

Soil Conditions – Acceleration Map

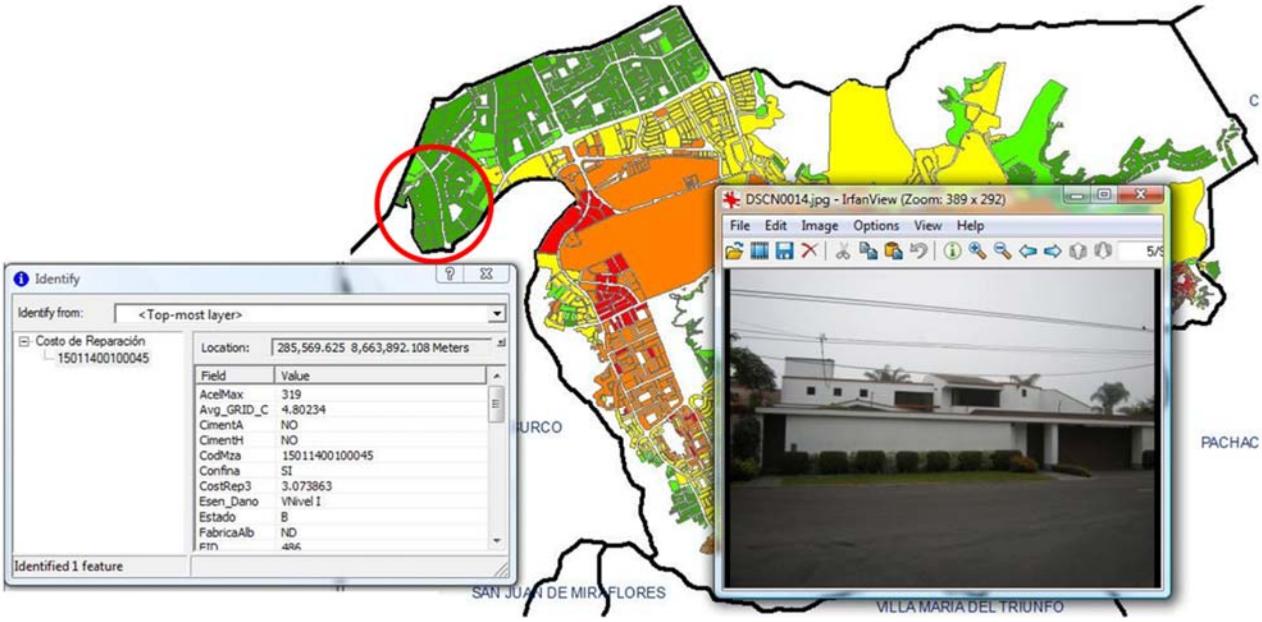


Soil Type	Description	Amp. Factor
S1	Rocks	1.0
S2	Intermediate	1.2
S3	Soft soil	1.4
S4	Special case	To be determined

Acceleration Map
for and Earthquake Scenario

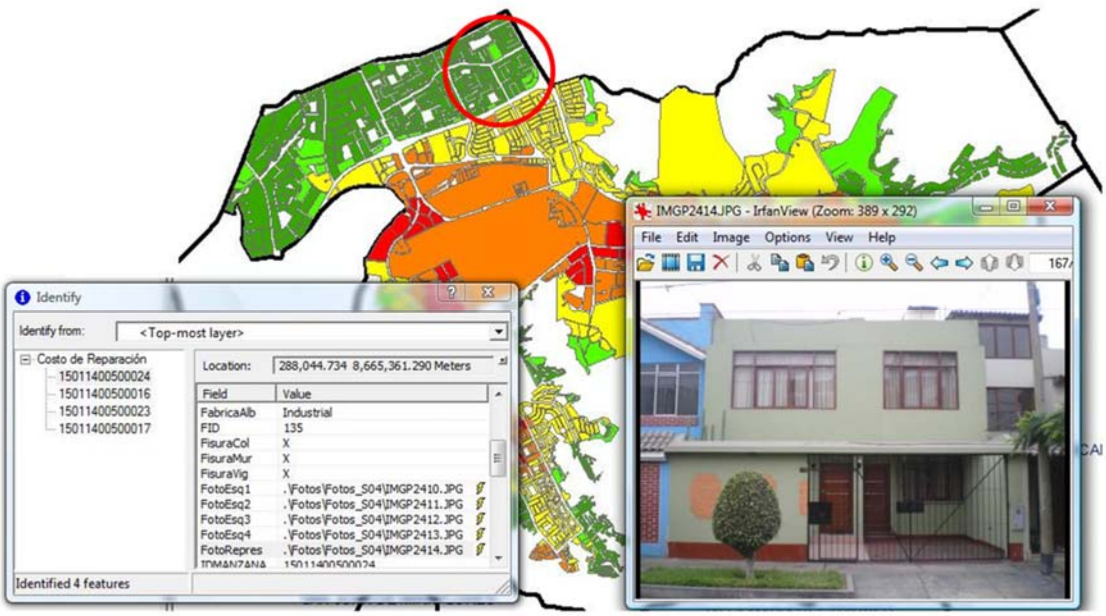
Structural Characteristics of Buildings

High social class



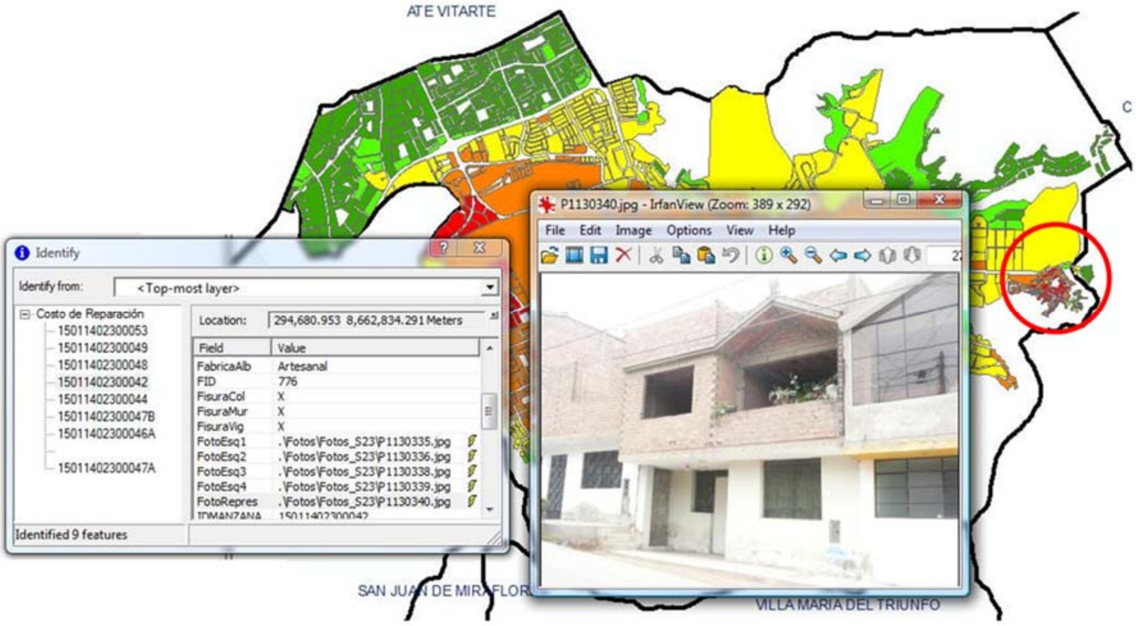
Structural Characteristics of Buildings

Middle social class



Structural Characteristics of Buildings

Low social class

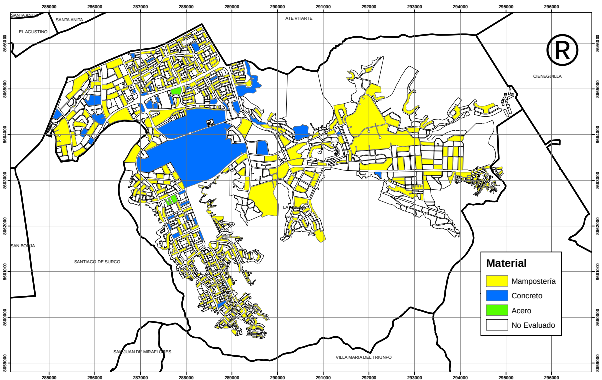


Structural Characteristics of Buildings Cadastral information

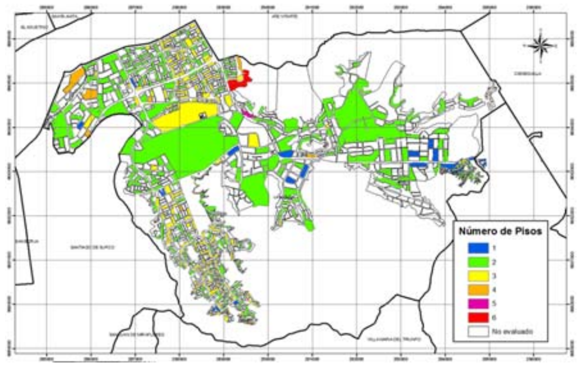
Field	Value	Description
Use	0	Empty
	1	Individual House
	2	Multifamily House
	3	Commerce
	4	Public buildings (School, Hospital, Police)
Material	0	Empty
	1	Adobe or quincha
	2	Masonry
	3	Reinforced concrete
	4	Others
Conservation	0	Empty
	1	Good
	2	Regular
	3	Bad
	4	Very bad
Height	Number	Number of stories

Thematic Maps

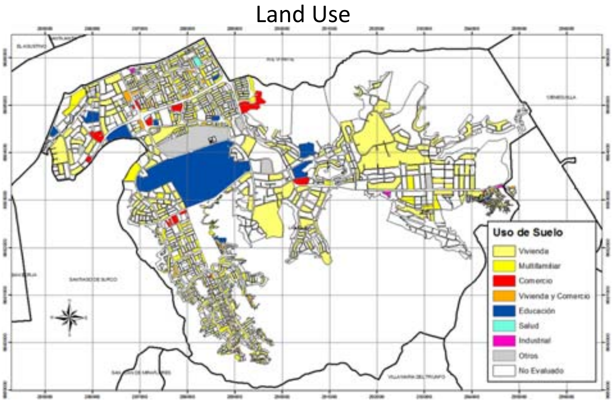
Material



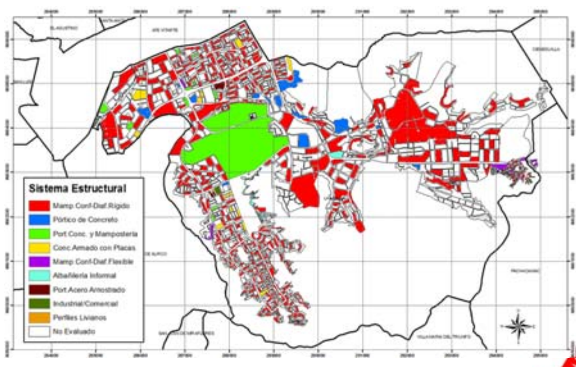
Number of Stories



Land Use

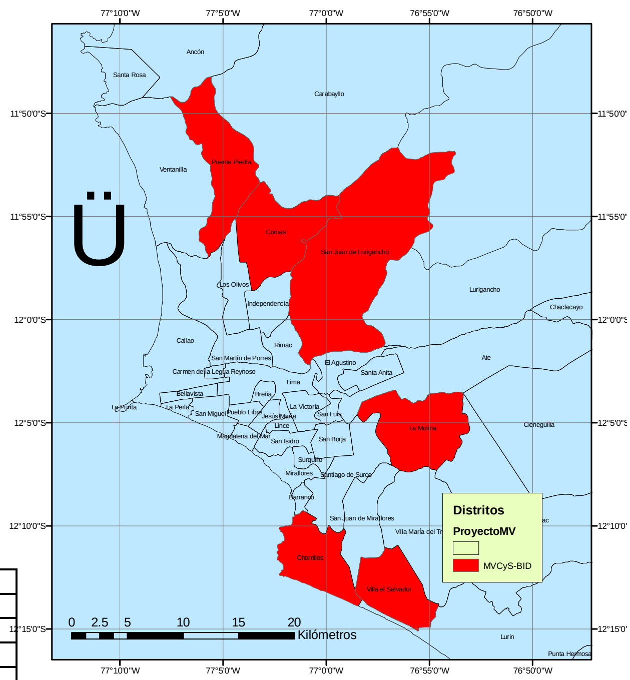


Structural System



6 Districts in Lima Under Detailed Study

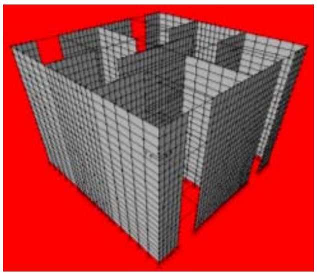
- La Molina
- Chorrillos
- Villa el Salvador
- San Juan de Lurigancho
- Comas
- Puente Piedra

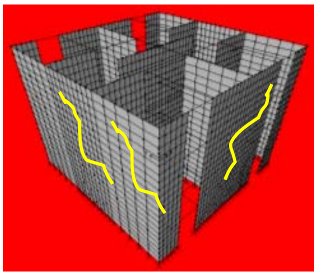


Distrito	Área(km2)	Población aproximada en miles
Chorrillos	38.9	262.6
Villa el Salvador	35.5	381.8
San Juan de Lurigancho	131.3	898.4
La Molina	65.8	132.5
Puente Piedra	71.2	233.6
Comas	48.8	487

Aproximatelly: 2.4 millon peoples

Adopted seismic Risk Evaluation


Building


Earthquake damage

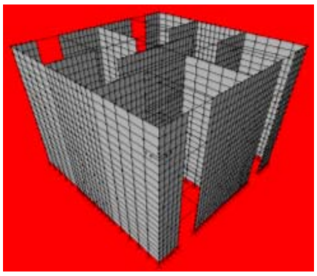
- Take plaster of walls S/.
- Put wire mesh S/.
- Put new plasterS/.
- Paint S/.

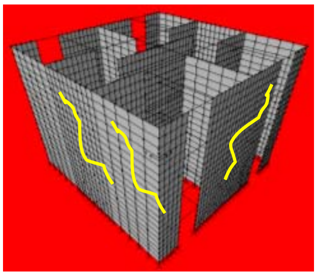
Retrofitting Cost

Retroffiting Cost = Function (Structure Type, PGA, Damage level)

- Structure Type → Urban Inventory
- PGA → Seismic Microzoning
- Damage level → Vulnerability Laboratoty Test

Adopted seismic Risk Evaluation


Building


Damage Level

Fundamental Period
T= 0.07 Np (1+ 0.75. Z. g/981)

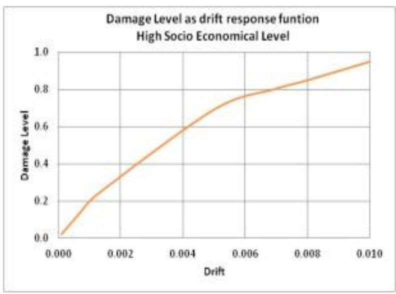
Sa = Aceleración on Microzone

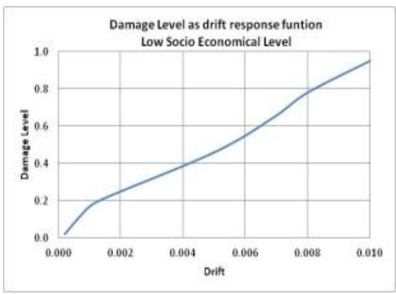
w= 2π/T
Sd= Sa /w^2

γe= Sd H =drift

γi=γe x (0.75 R)

γ= FR* γi



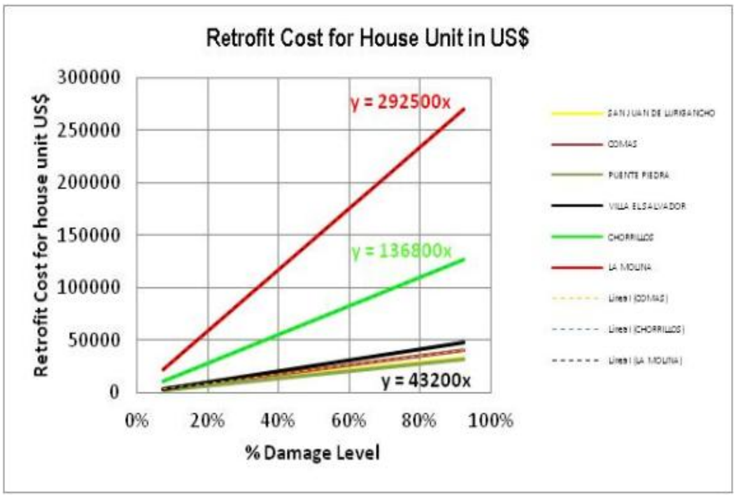


$$\gamma = \frac{(X_i - X_{i-1})}{h} = \left(\frac{\left(\frac{ZUSC}{R}\right)}{\left(\frac{2\pi}{T}\right)^2} \right)(0.75\mu)$$

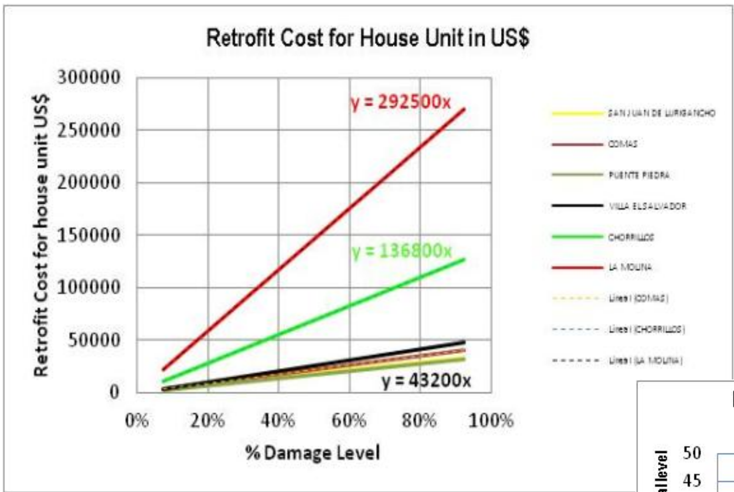
USING DAMAGE MATRIX AND PARAMETERS FROM 6 DISTRICT STUDY A RATIO DAMAGE LEVEL AND RETRIFFTING COST WAS DEVELOPED

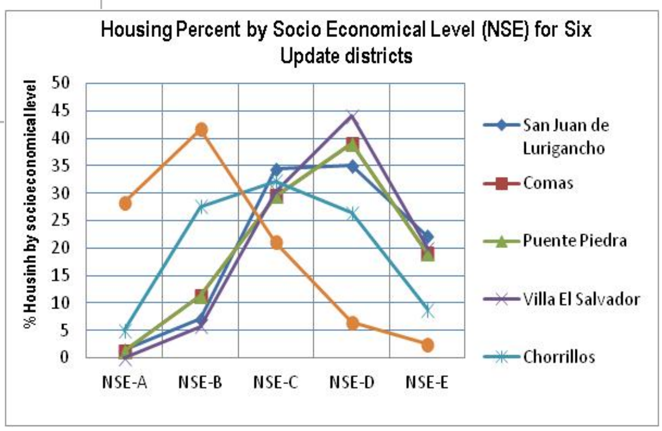
Proyecto CISMID-PGT-BID

Distrito	Lotes/Mza	Area Lote Prom(m2)	Reposición (US$/m2)
SAN JUAN DE LURIGANCHO	20	130	275
COMAS	18	160	300
PUENTE PIEDRA	18	160	235
VILLA EL SALVADOR	20	130	400
CHORRILLOS	18	160	950
LA MOLINA	18	250	1300



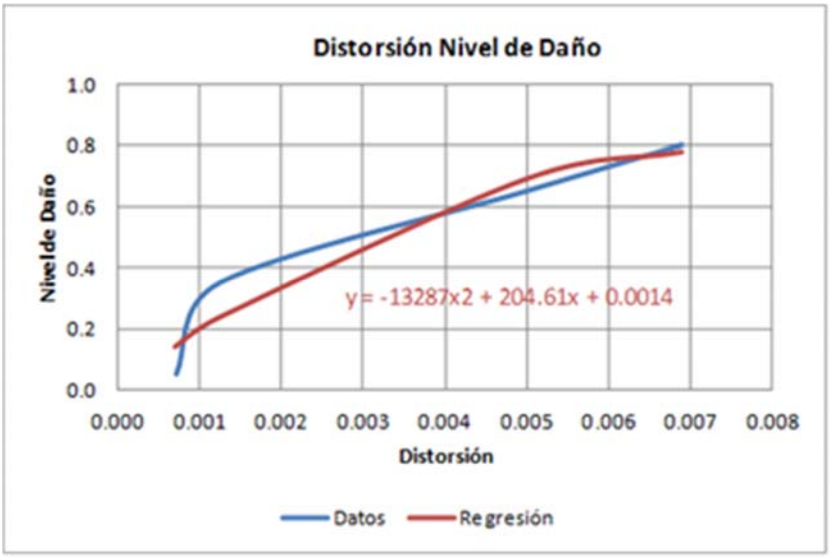
RATIO DAMAGE AND RETROFIT COST BASE ON SOCIOECONOMICAL LEVEL





(Source: APEIN)

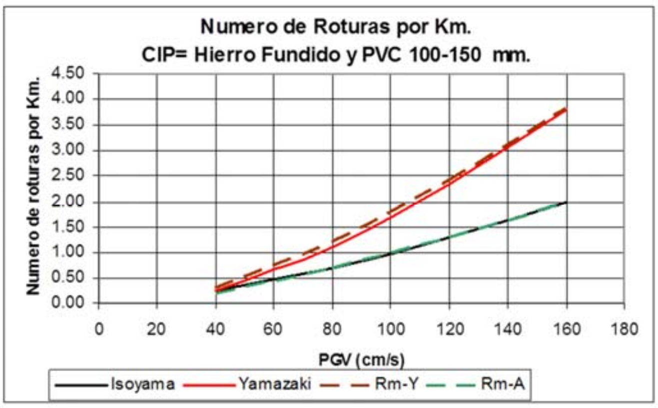
Structural Characteristics of Buildings Development of Building Damage Curve

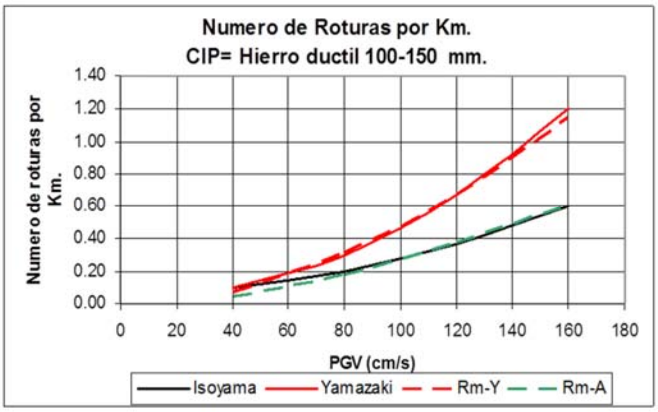


Damage curve based on the drift of the building

The damage curve will depend on the parameters mentioned in the table showed before.

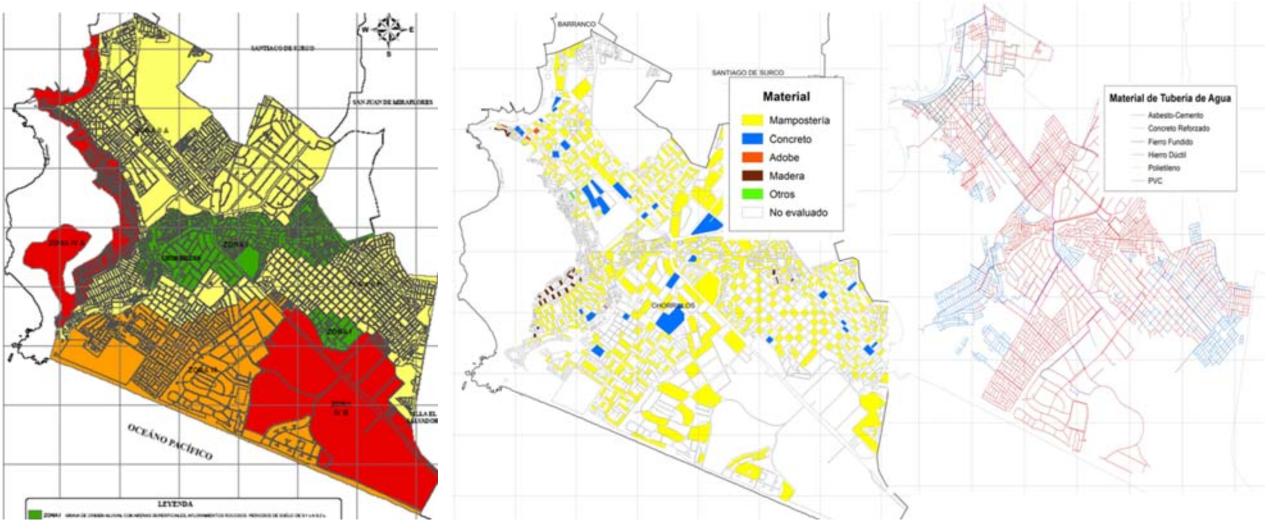
Structural Damage of Water Pipes





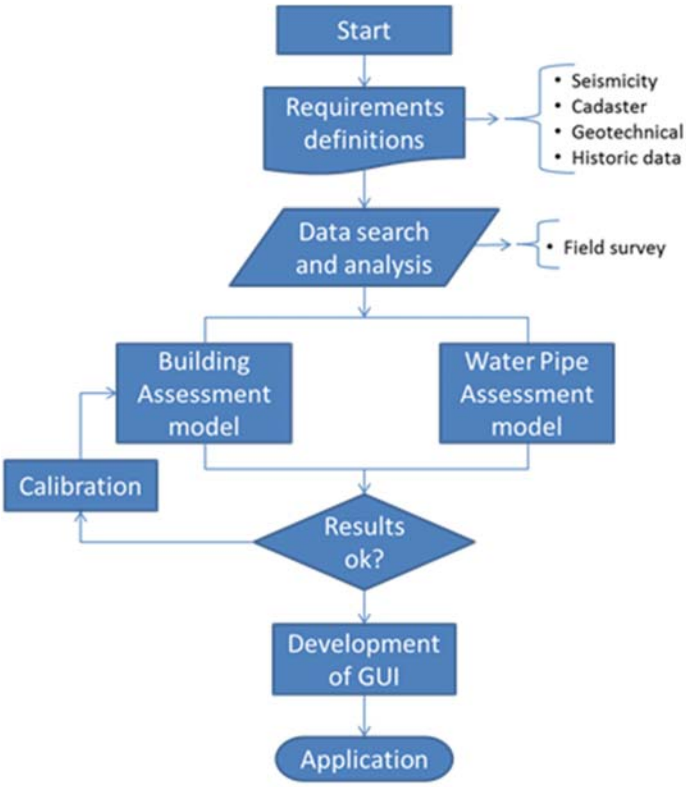
Number of breaks per kilometer for different type of water pipe

Data Integration in a GIS Platform



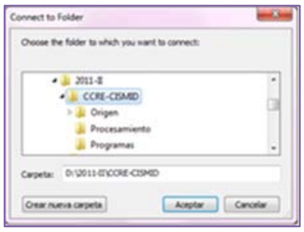
Soil Conditions + Building Information + Water pipe information

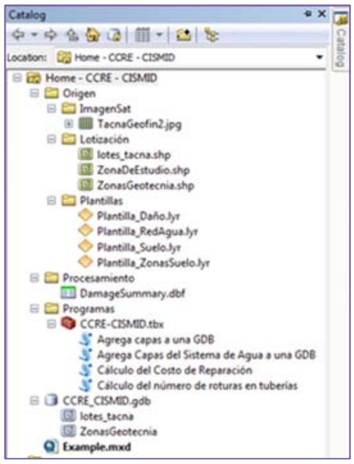
Analysis Tool Development



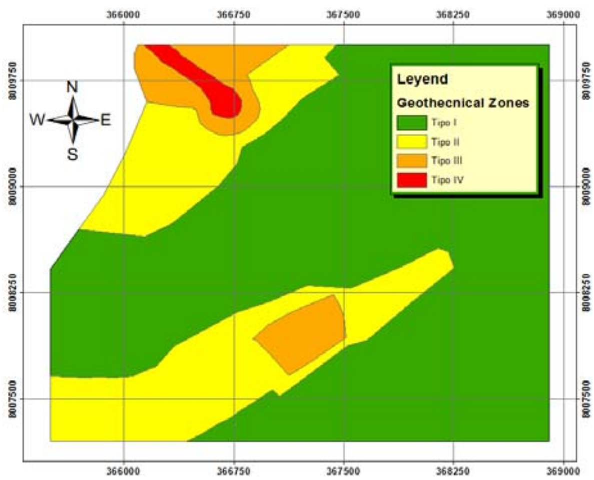
Analysis Tool Development

- Development within the commercial software ArcGIS v10.0
- By programming in Python language
- Using Arcpy and Math modules
- The program offers flexibility to change building and soil parameters



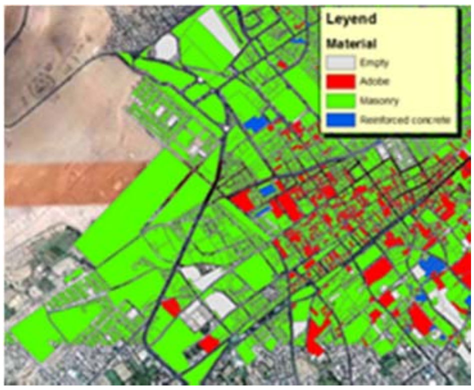


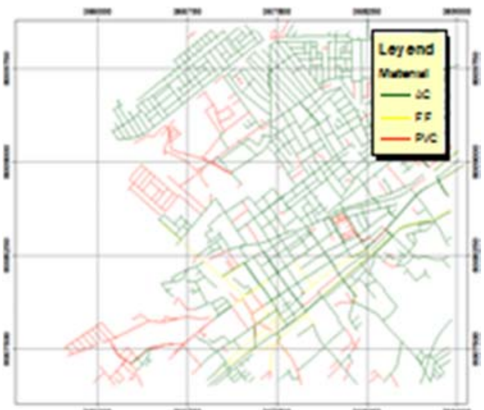
Analysis Tool Application
Tacna City – Southern Peru



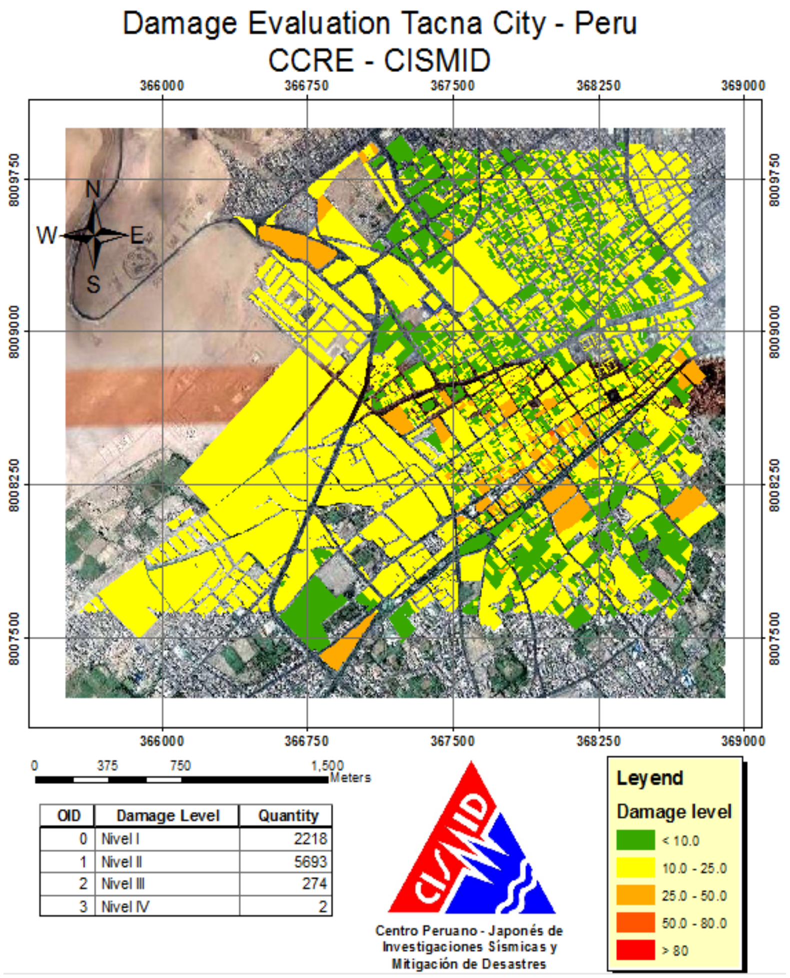
Soils

Buildings





Water pipes



Analysis Tool Application

Tacna City – Southern Peru

Conclusions

- An automatic tool to evaluate the building and water pipe damage has been developed.
- To carry out the damage assessment procedure geotechnical, cadastral and pipe information is necessary. However, the building information could be in different area sizes: Lot, Block or Zone, depending the quantity or quality of the data.
- The tools can be applied to cities with similar building, pipe and soil conditions similar to Lima city.
- To obtain empirical relationships between acceleration and level of damage, it has processed a wide variety of cases, so the application is well calibrated for this type of buildings and soils.
- Regarding the analysis for water pipe some additional curves may be develop, to cover the variety of pipe materials and diameters, but this tools can give a good figure about the possible damage in case an severe earthquake.
- Statistical information can be obtained from the final thematic maps and can be used to make prevention and mitigation plans.

Group 4 and 5 Conclusions

- Group 4
  - Inventory map for Lima City and Tacna City based on Satellite Imagery and Census Data will continue to developing
  - To improve the inventory data Peruvian Counterpart will contact to Municipalities to get cadastral data.
  - For building high LIDAR may be used, for this purpose Peruvian counterpart will request the quotation to a private company.
  - Sharing PRISM satellite data with INDECI and CONIDA will be carried out to analyse DSM.
  - Future activities:
    - Complete the building inventory for Lima and Tacna
    - Join effort with Group 1 and 3 to develop damage assessment maps
    - Developing damage detection techniques
    - Installation of permanent GPS monitoring system at CISMID
    - Setup of several GPS monitoring point and conduct the correspond measurement
- Group 5
  - New Peruvian Government planning issues for Pisco Recovery was discussed.
  - Japanese Urban Planners will study the future land use of Pisco and will provide some recommendations
  - Master plan map of Pisco will be share and feedback will discussed by Peruvian and Japanese specialists.
  - Propose a way to increase the peoples sensitivity related to Disaster Management Issues.

Group 4 and 5 Conclusions
Master Plan for Pisco 2011 - 2021