Xavier University
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Social Development Office

VISAYAS – MINDANAO
MONITORING & EVALUATION NETWORK FORUM
Cagayan de Oro City
03 December 2024 I Limketkai Luxe Hotel

# Infrastructure Resilience: Tools & Experiences

*Dexter S. Lo*

# (1) Buildings

# (2) Fragility

# (3) Infrastructure

# Buildings Assessment:

- Structural
- Electrical
- Electronics
- Mechanical
- Fire
- Sanitary / Plumbing
- Locational
- Accessibility, etc...







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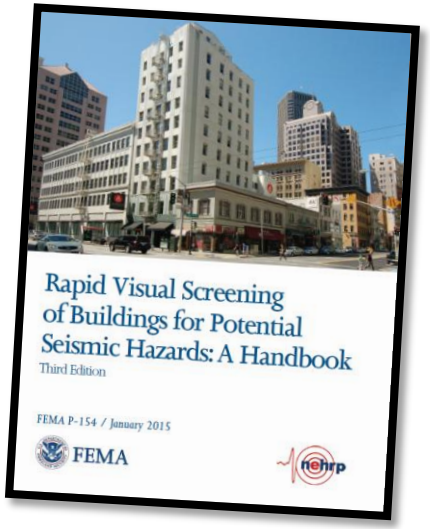
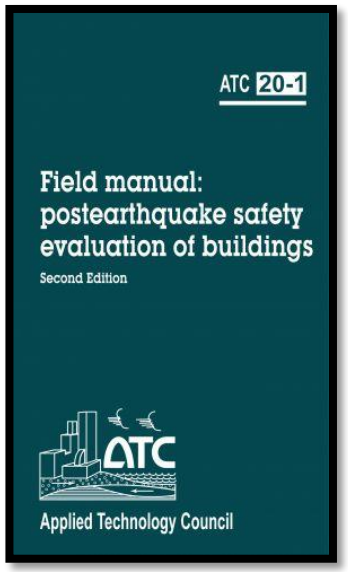
# Buildings Assessment: SEISMIC EVALUATION ➔ HOW?

## ➢ Structural

### Pre-Earthquake
Structural Evaluation

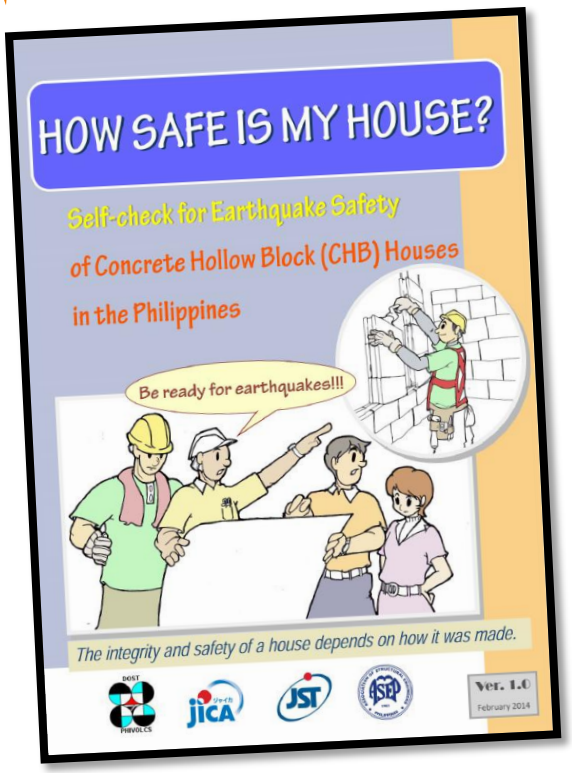

### Post-Earthquake
Structural Evaluation

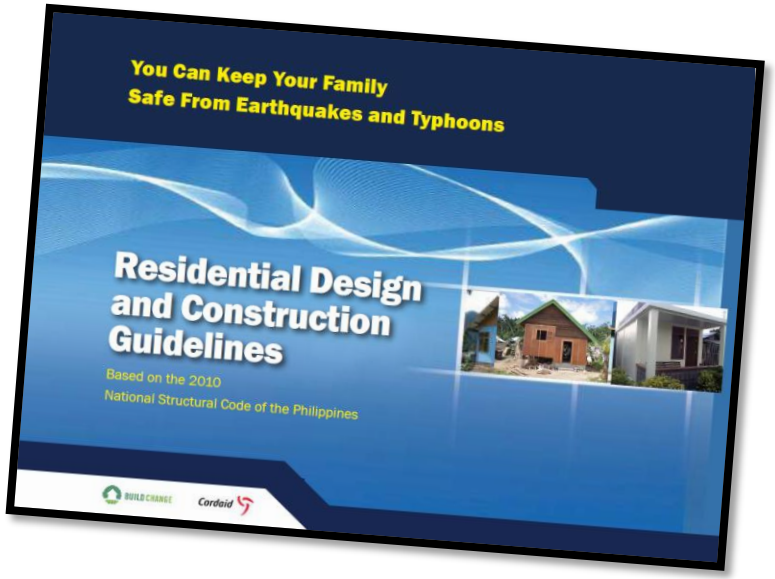
# Buildings Assessment: SEISMIC EVALUATION ➔ HOW?

## ➢ Structural

### Pre-Earthquake

Structural Evaluation



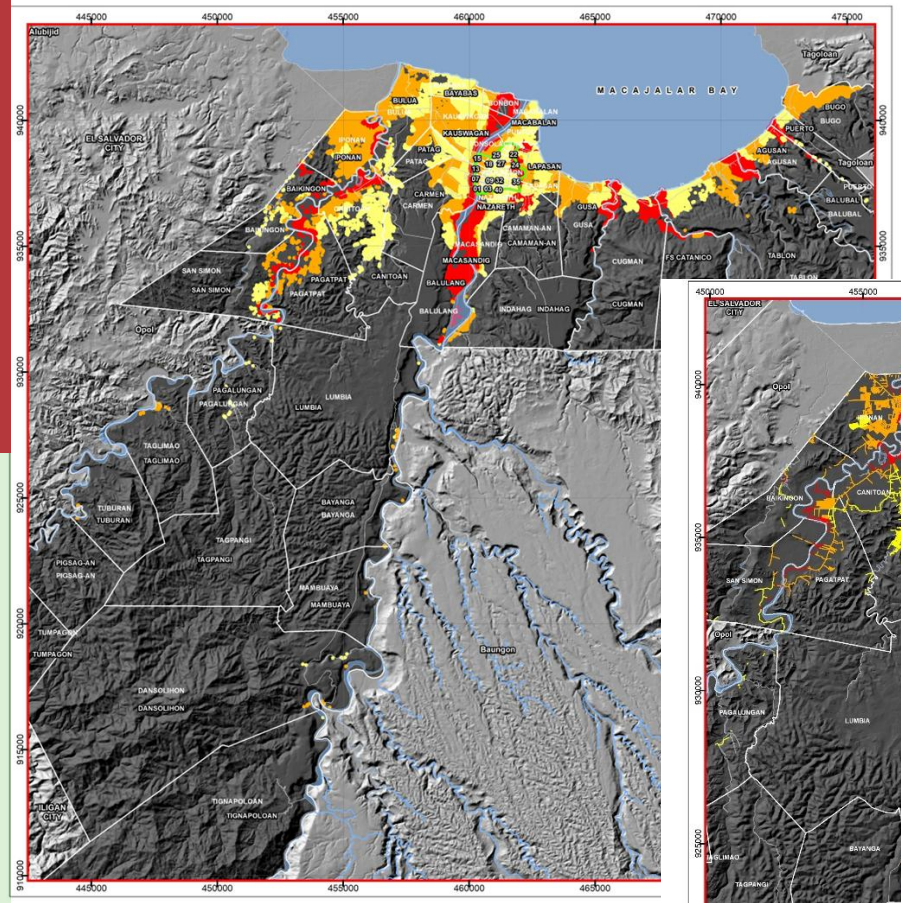
# Climate and Disaster Risk Assessment

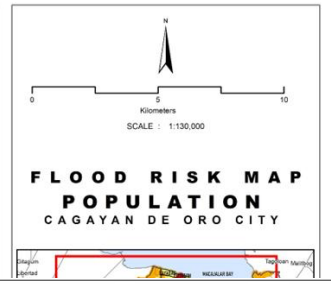
LGU Cagayan de Oro City 2023

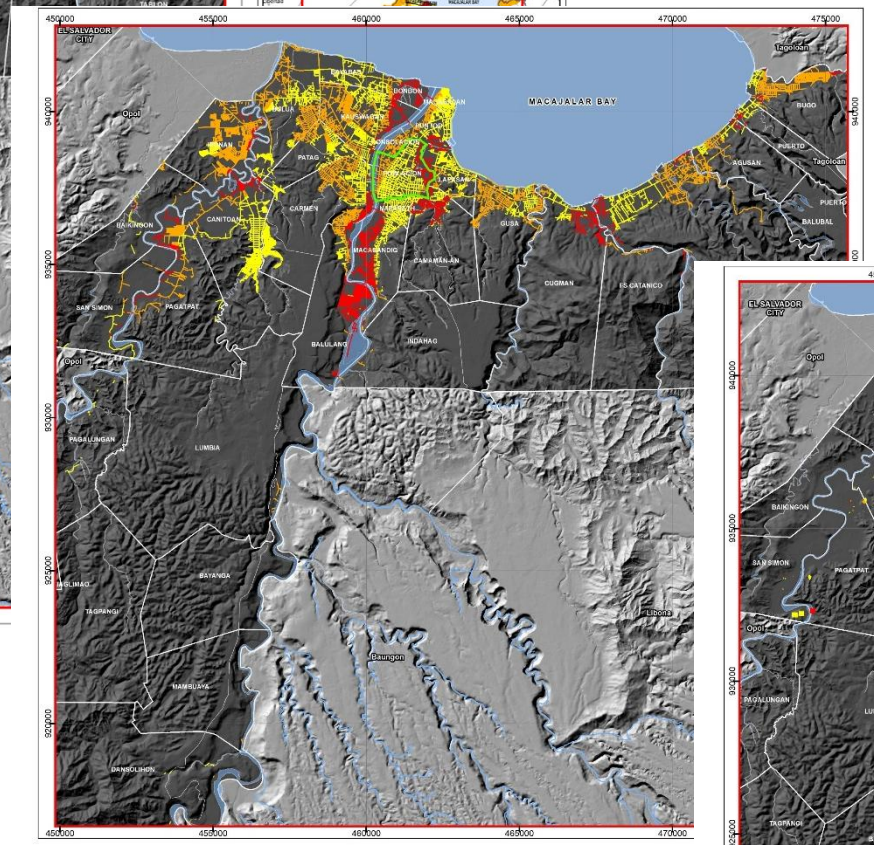
in the case of...

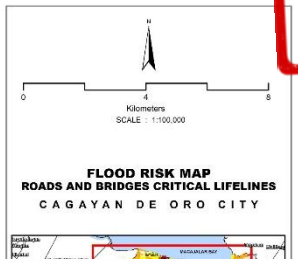
# Local Disaster Risk Reduction & Management Plan 2022-2030

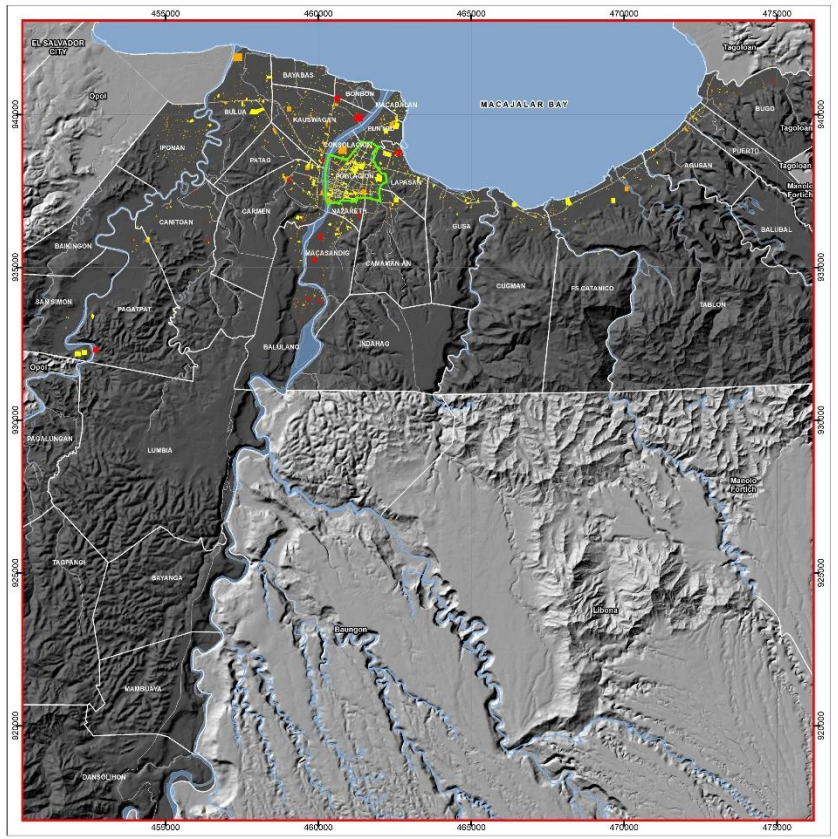
Cagayan de Oro City

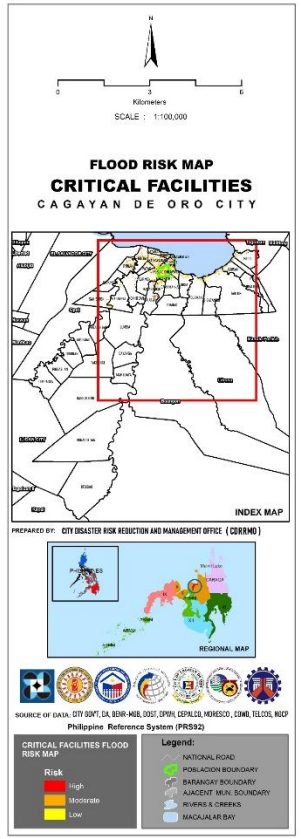
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# Climate and Disaster Risk Assessment

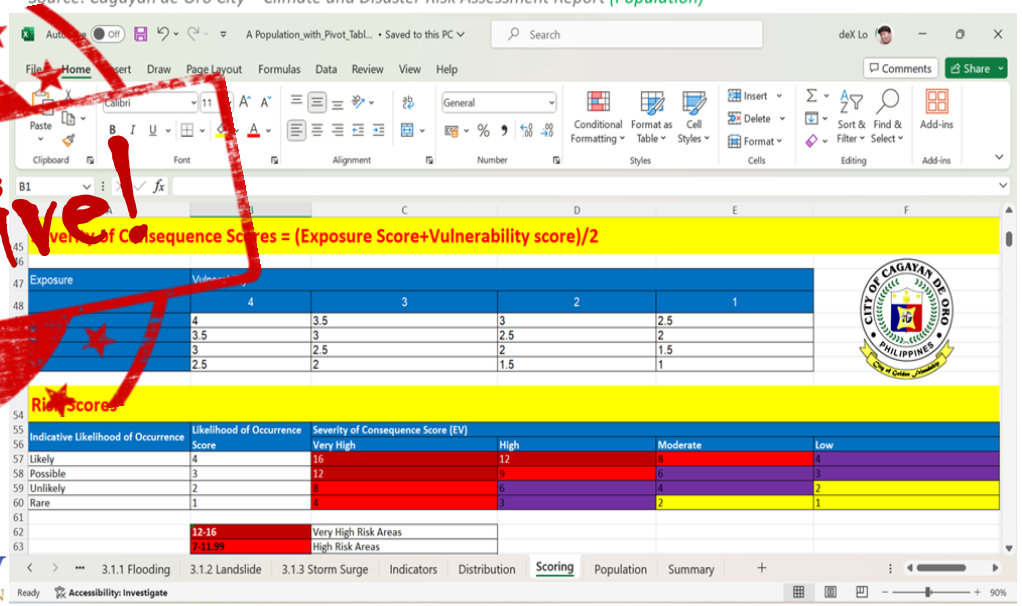
LGU Cagayan de Oro City 2023

**List of Risk Indicators and Corresponding Levels**

| INDICATORS | DATA LEVELS | SOURCES (guidelines, case studies, projects, etc.) |
|---|---|---|
| | | |
| **HAZARD** | | |
| Susceptibility | Low, moderate, high | HLURB Training module, HLURB (2015) |
| Likelihood of occurrence | 1, 2, 3, 4 | HLURB Training module, HLURB (2015) |
| Depth (flood, storm surge) | Measurement (1 meter, 2 feet, etc.) | HLURB Training module, HLURB (2015) |
| Magnitude score | 1, 0.66, 0.33 (if there are 3 levels, 1 being the highest) | HLURB Training module, HLURB (2015) |
| | 1, 0.75, 0.5, 0.25 (if there are 4 levels, 1 being the highest) | HLURB Training module, HLURB (2015) |

descriptive!

*Source: Cagayan de Oro City – Climate and Disaster Risk Assessment Report (Population)*




| SENSITIVITY | | |
|---|---|---|
| Informal Settlers (IS) | Number or percentage | HLURB Training module, HLURB (2015) |
| People living in dwelling units made from light materials or salvageable materials | Number or percentage | HLURB Training module, HLURB (2015) |
| Young dependents (<= 5 years old) | Number or percentage | HLURB Training module, HLURB (2015) |
| Old dependents (>= 65 years old) | Number or percentage | HLURB Training module, HLURB (2015) |
| Persons with disabilities (mental and physical)/ chronic diseases | Number or percentage | HLURB Training module, HLURB (2015) |
| Families below the poverty threshold | Number or percentage | HLURB Training module, HLURB (2015) |
| Malnourished Individuals | Number or percentage | HLURB Training module, HLURB (2015) |

| Adaptive capacities | | |
|---|---|---|
| People with access to infrastructure-related mitigation measures | Number or percentage | HLURB (2015) |
| People with access to financial assistance | Number or percentage | HLURB Training module, HLURB (2015) |
| People with capacity and willingness to retrofit or relocate | Number or percentage | HLURB Training module, HLURB (2015) |
| People with access to information | Number or percentage | HLURB Training module, HLURB (2015) |
| People who benefit from government investments on CCA-DRR | Number or percentage | HLURB Training module, HLURB (2015) |
| People who benefit from 4Ps or related government programs | Number or percentage | Cadag (2018) |
| Plan for relocation (barangay, municipal plan, national, NHA, etc.) | Yes or no; none, poor, fair, good | Cadag (2018) |
| Livelihood programs | Yes or no; none, poor, fair, good | Cadag (2018) |

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Local Disaster Risk Reduction & Management Plan 2022-2030
Cagayan de Oro City

*Table G 1. VULNERABILITIES OF CLUSTERED EXPOSURE ELEMENTS AGAINST GEOLOGICAL HAZARDS,*
**Pillar 1: Prevention and Mitigation**

| PILLAR 1: PREVENTION AND MITIGATION | | | |
|---|---|---|---|
| **INFRASTRUCTURE** | **LOCAL ECONOMY** | **HUMAN DEVELOPMENT** | **ENVIRONMENT** |
| **Housing**<br>Relocation of at-risk households (those in danger zone) cannot be enforced quickly (due to high demand)<br>(EIL, T)<br>(PPA 4.4)<br><br>Presence of settlements in landslide-prone areas<br>(EIL)<br>(PPA 4.4 and 4.8)<br><br>**Buildings**<br>Key facilities located near the shoreline (coastal road serves as sea wall) and riverbank<br>(T)<br>(PPA 4.6 and 7.2)<br><br>Unavailability of assessment report on the structural integrity of buildings (database/GIS mapping)<br>(E)<br>(PPA 2.3, 2.4, 4.2 and 4.10)<br><br>Poor Building Management System on inter-office access of RDANA in infrastructures, buildings, and similar structures and roads<br>(E, EIL, T)<br>(PPA 2.5 and 4.10)<br><br>**Lifelines: *Telecommunications***<br>Unavailability of application/mobile system for emergency notification<br>(E, EIL, T)<br>(PPA 2.6) | | **Social Protection**<br>Lack of localized maps for DRRM<br>(E, EIL, T, L)<br>(PPA 2.4)<br><br>Insufficient data on subsidence; lack of knowledge on the exact location of areas prone to subsidence; could be an associated hazard of earthquake, flood, etc.<br>¾ of the city's total population occupied ¼ of the city's total land area located in urban area<br>(S)<br>(PPA 2.8)<br><br>Lack of updated risk assessment at the barangay level<br>(E, EIL, T, S, L)<br>(PPA 2.2 and 2.3) | **Socio-ecosystem**<br>34 Barangays are susceptible to landslide<br>(EIL)<br>(PPA 4.4 and 4.8) |


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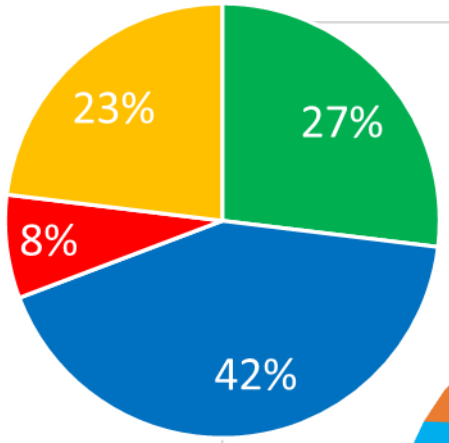
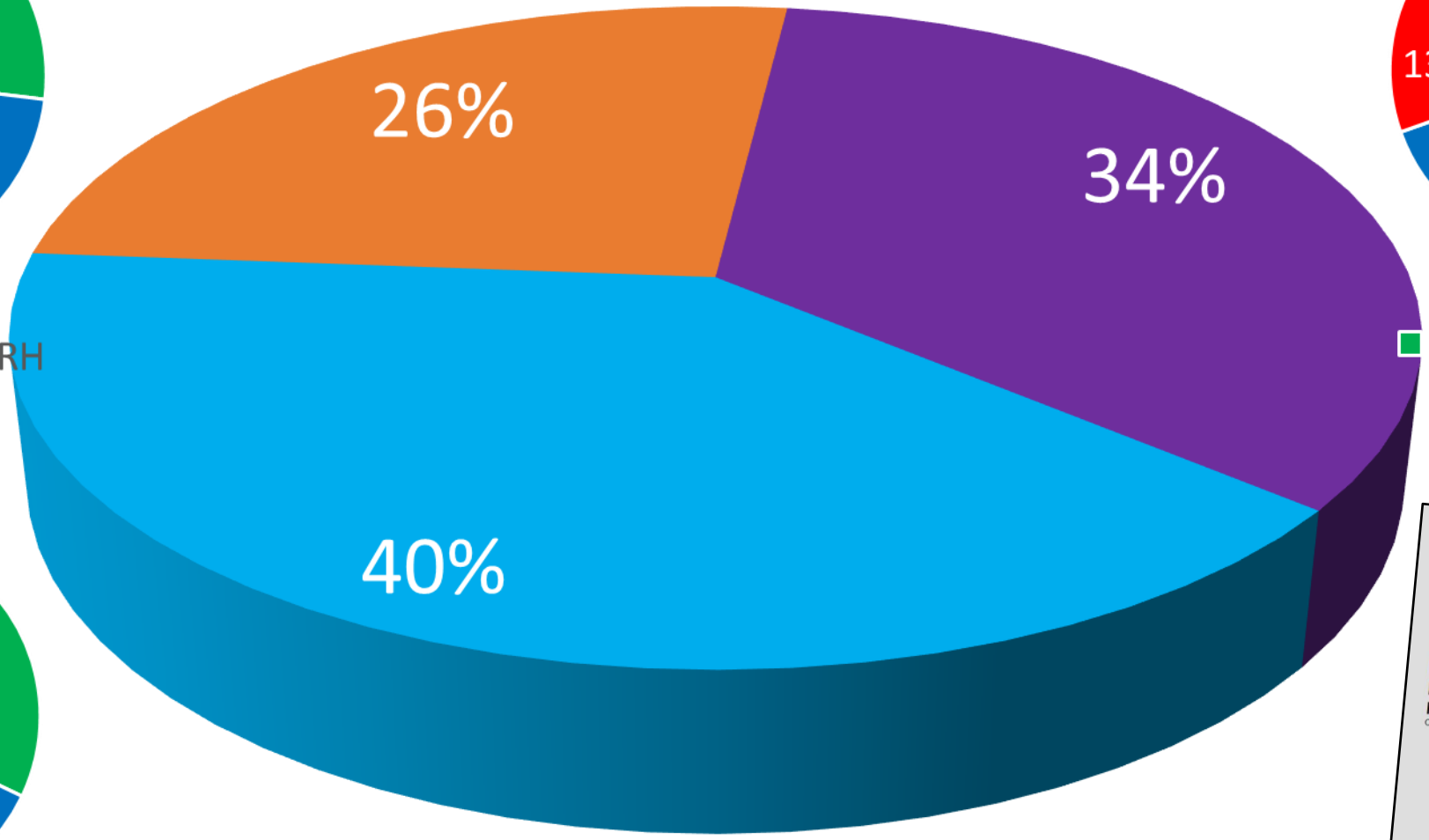
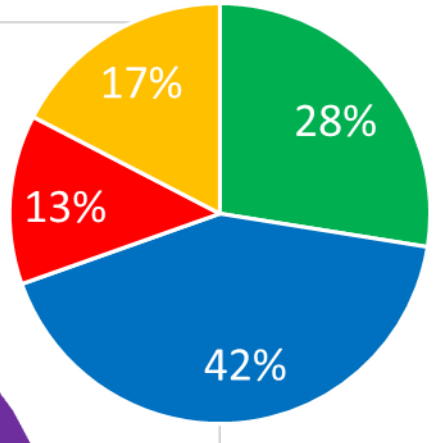
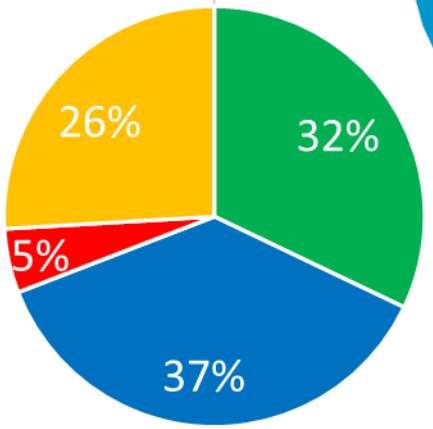
# PPAs by Hazard Categories & Thematic Pillars





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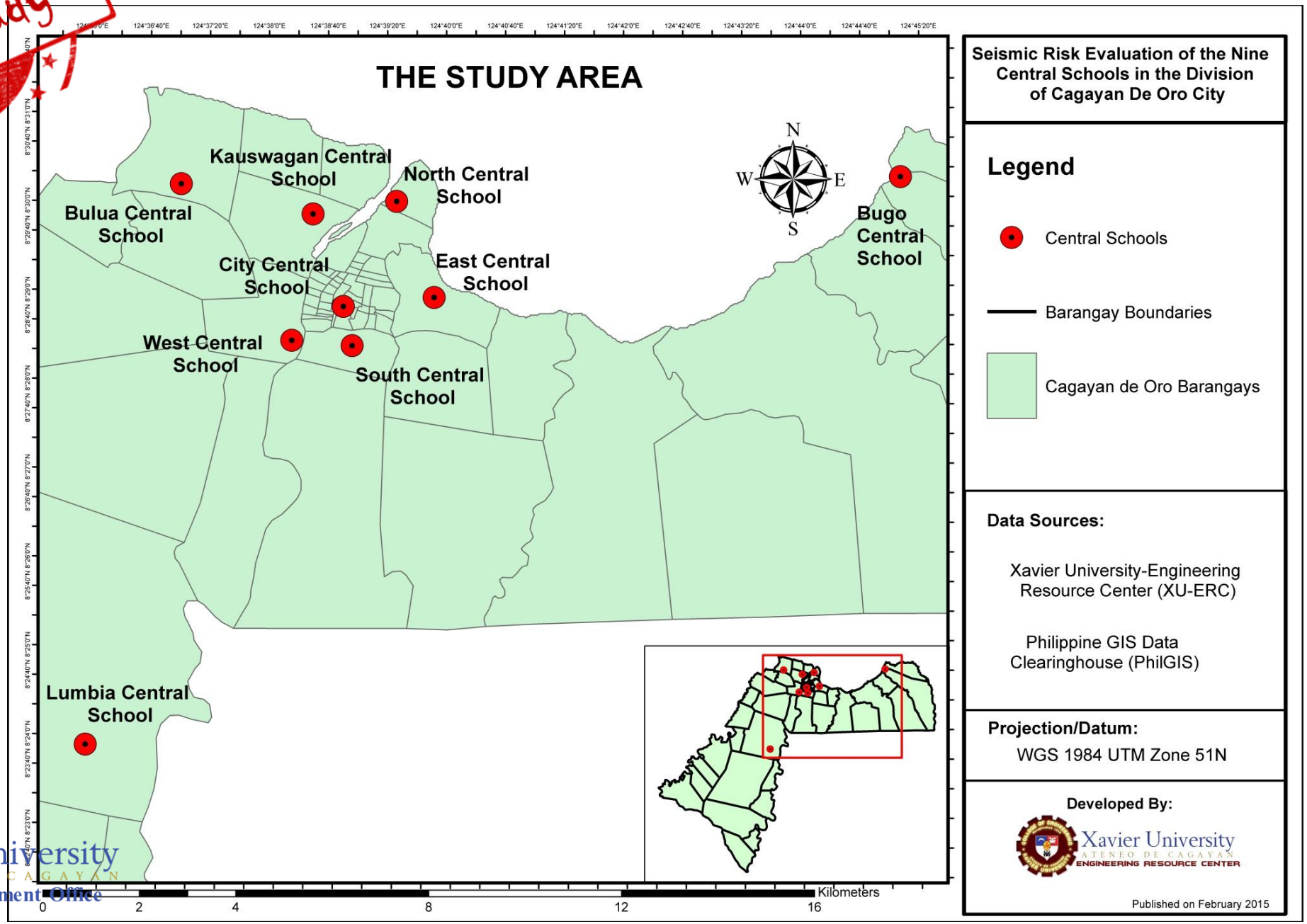
**153 PPAs to achieve 27 Outcomes**

*Note: Some PPAs are repeated because they address multiple hazards.*

# Seismic Risk Evaluation of the Nine Central Schools in the Division of Cagayan de Oro City (2015)

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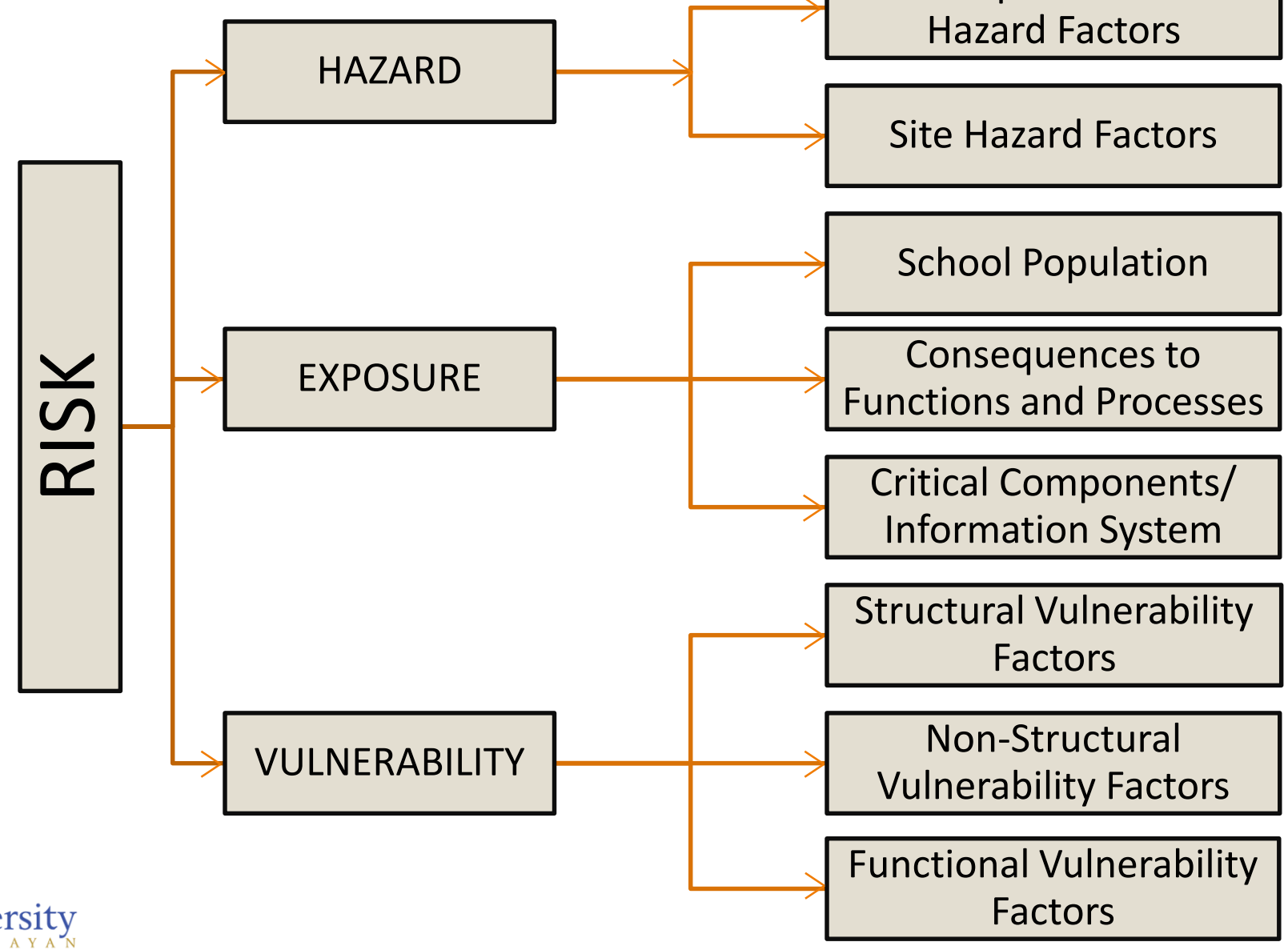
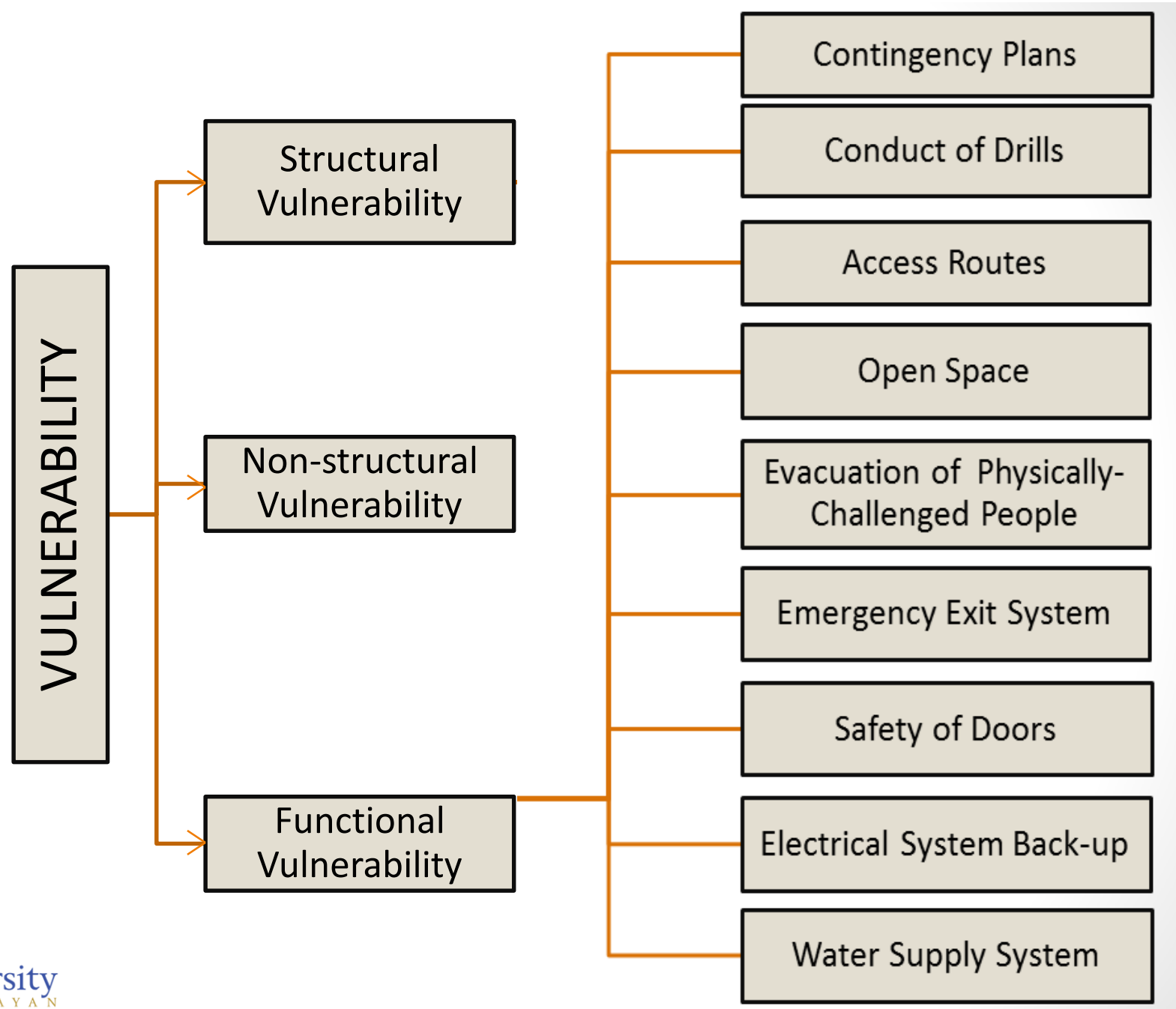
# Risk Parameters




Case Study

*..adapted from Brizuela & Oreta (2013)*




Case Study



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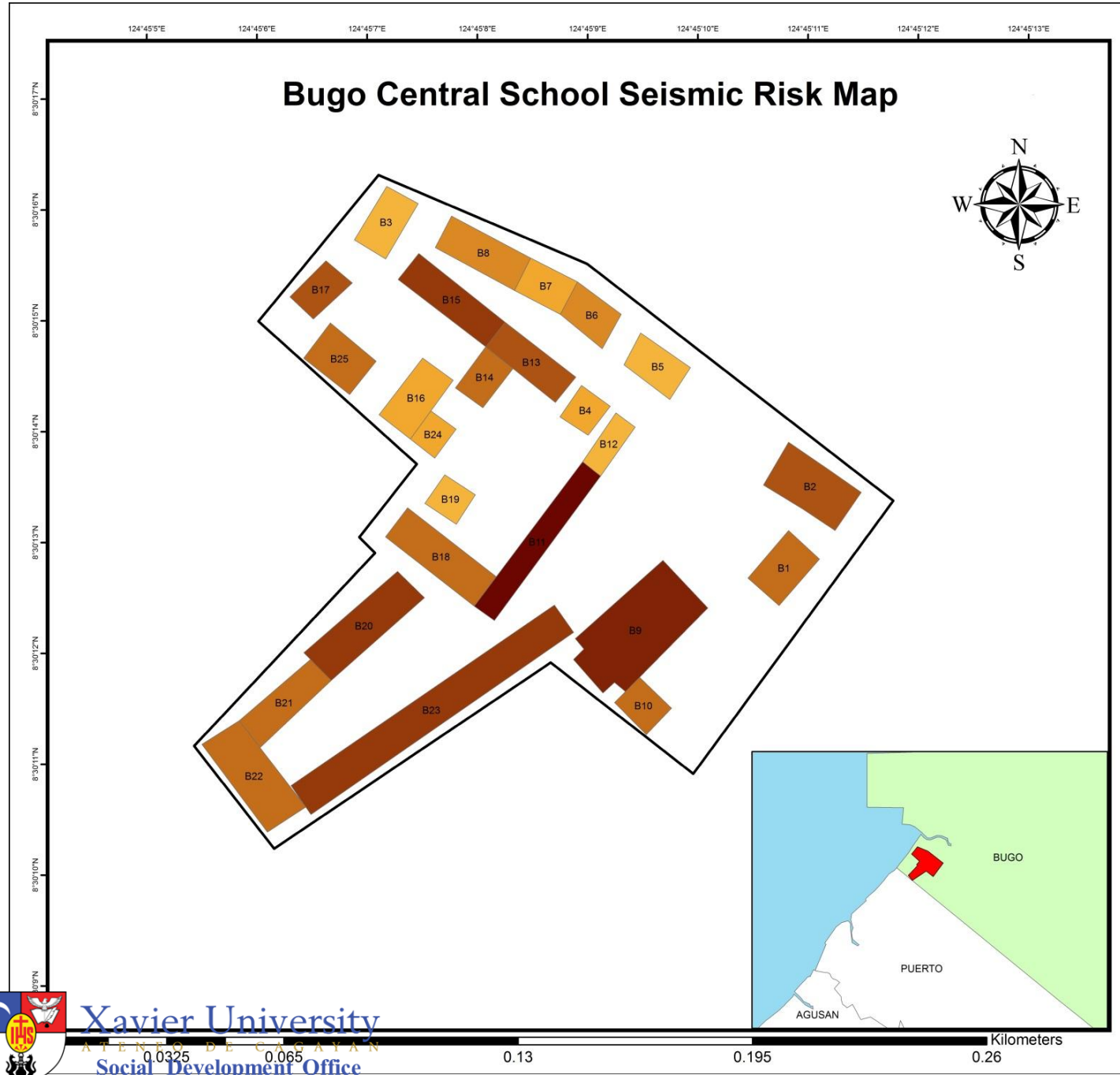



**Seismic Risk Evaluation of the N… Central Schools i… of Cagayan De…**

## Legend

School Boundaries

School Buildings

**Bugo Central Seismic Risk Ind…**

- 0.00
- 0.01 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- 3.01 - 4.00
- 4.01 - 5.00
- 5.01 - 6.00
- 6.01 - 7.00
- 7.01 - 8.00
- 8.01 - 9.00
- 9.01 - 10.00
- 10.01 - 11.00
- 11.01 - 12.00

**Note:**

Earthquake Sou…
Magnitude less t…
(Source Type …

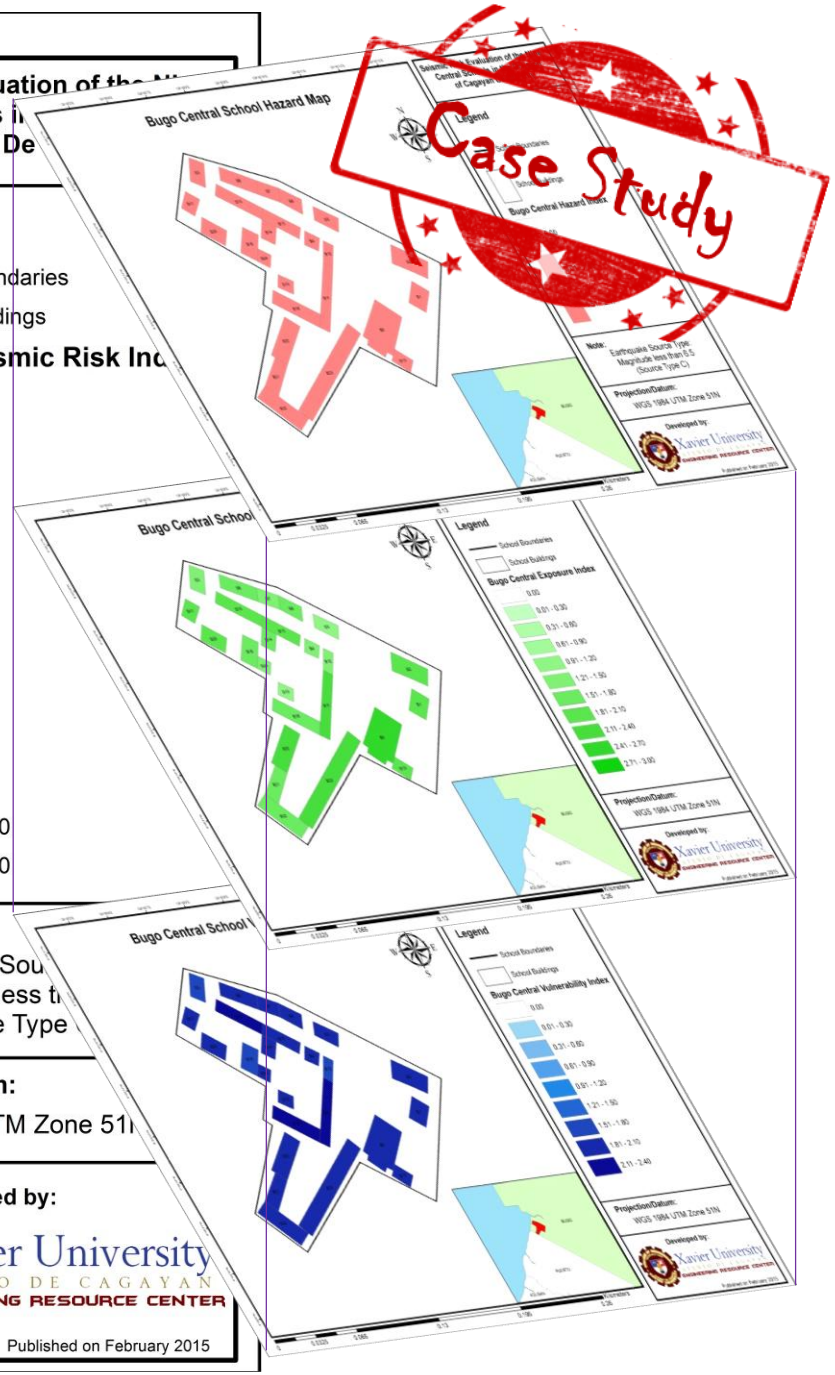
**Projection/Datum:**

WGS 1984 UTM Zone 51…

**Developed by:**

Xavier University
ATENEO DE CAGAYAN
ENGINEERING RESOURCE CENTER

Published on February 2015




Case Study

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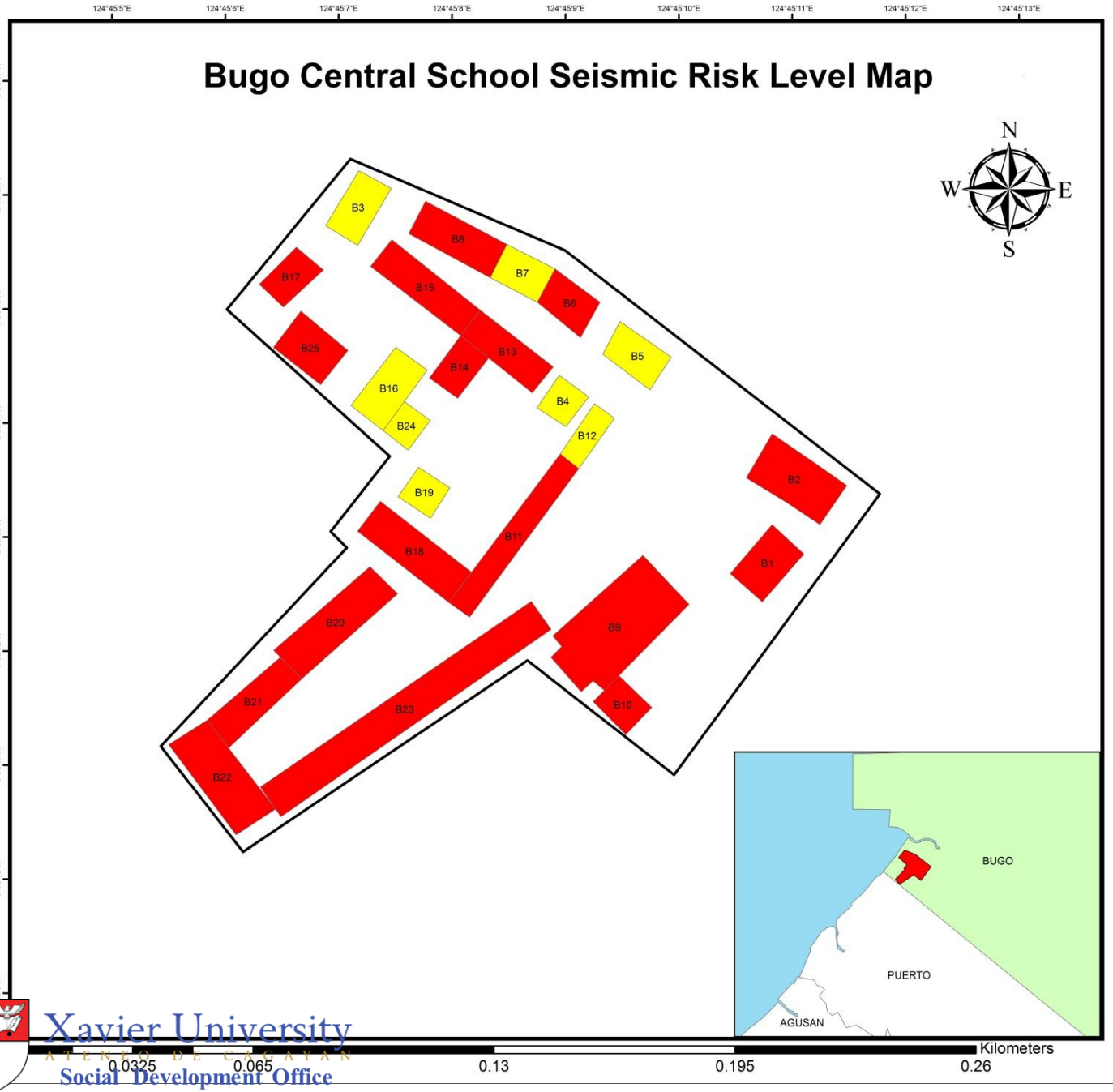
# Bugo Central School Seismic Risk Level Map




**Seismic Risk Evaluation of the N... Central Schools i... of Cagayan De...**

## Legend

- School Boundaries
- School Buildings

**Bugo Central Seism...**

- Low Risk
- Medium Risk
- High Risk

**Note:**
Earthquake Sou...
Magnitude less t...
(Source Type ...

**Projection/Datum:**
WGS 1984 UTM Zone 51...

**Developed by:**
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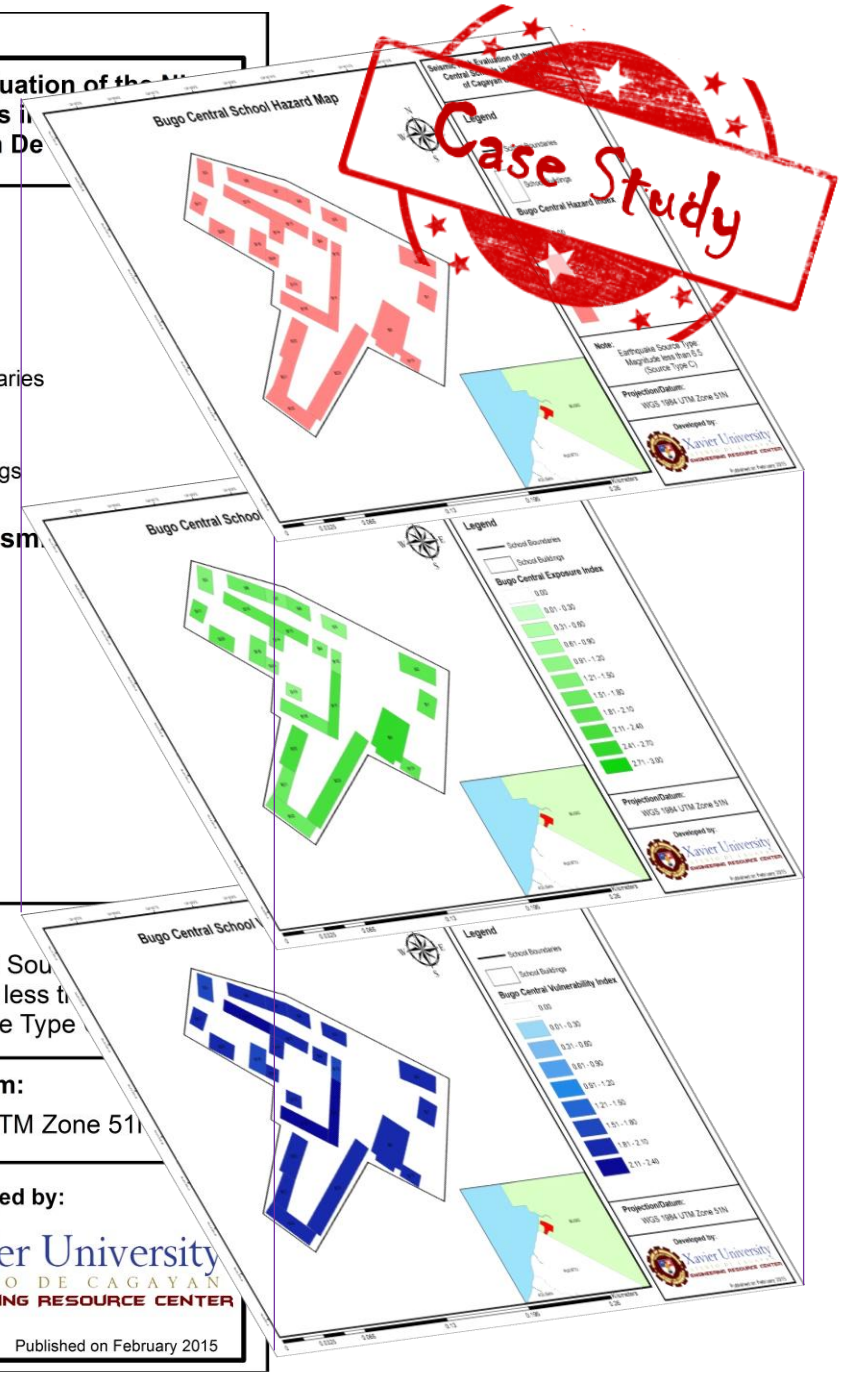
Published on February 2015

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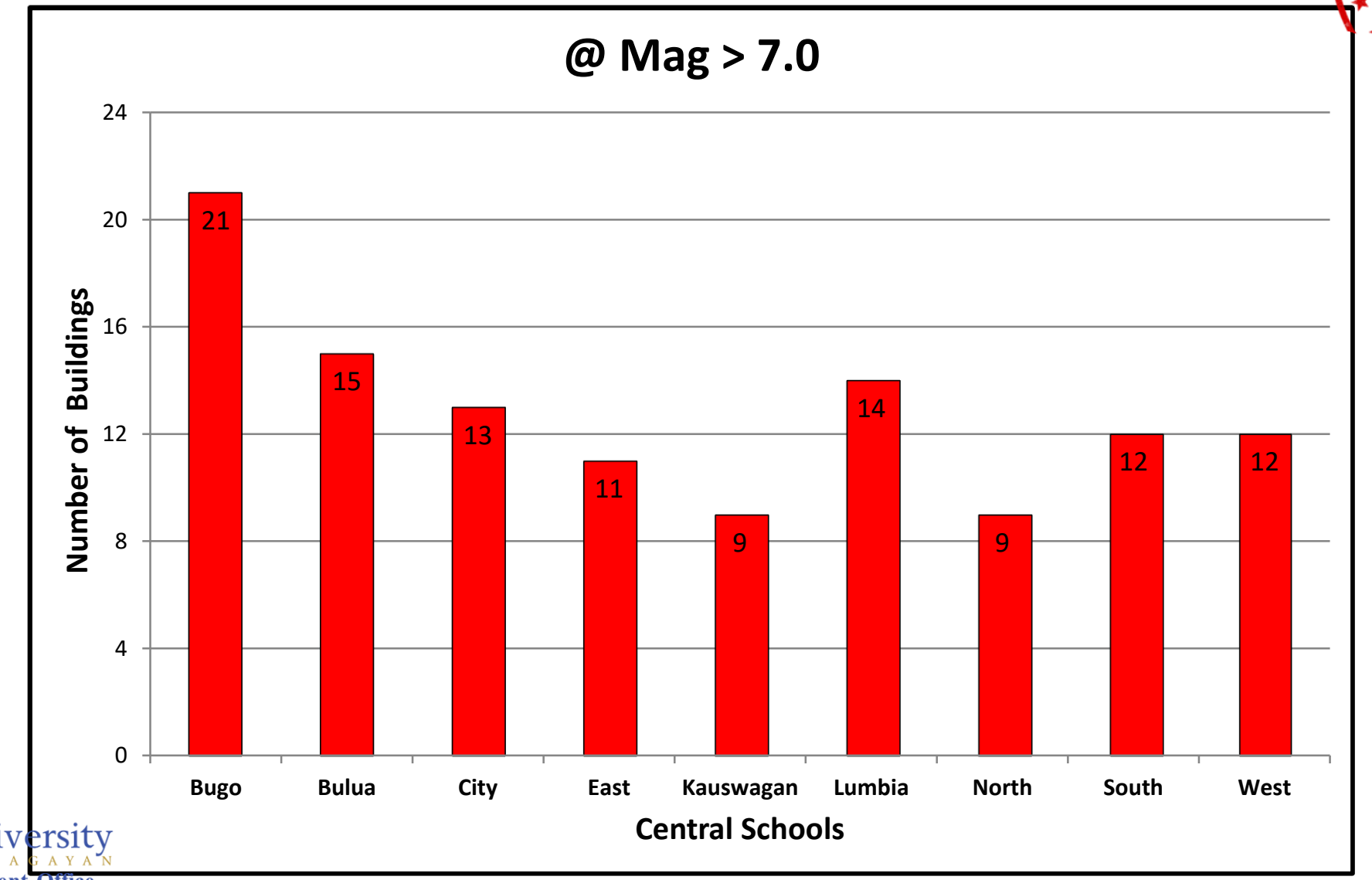
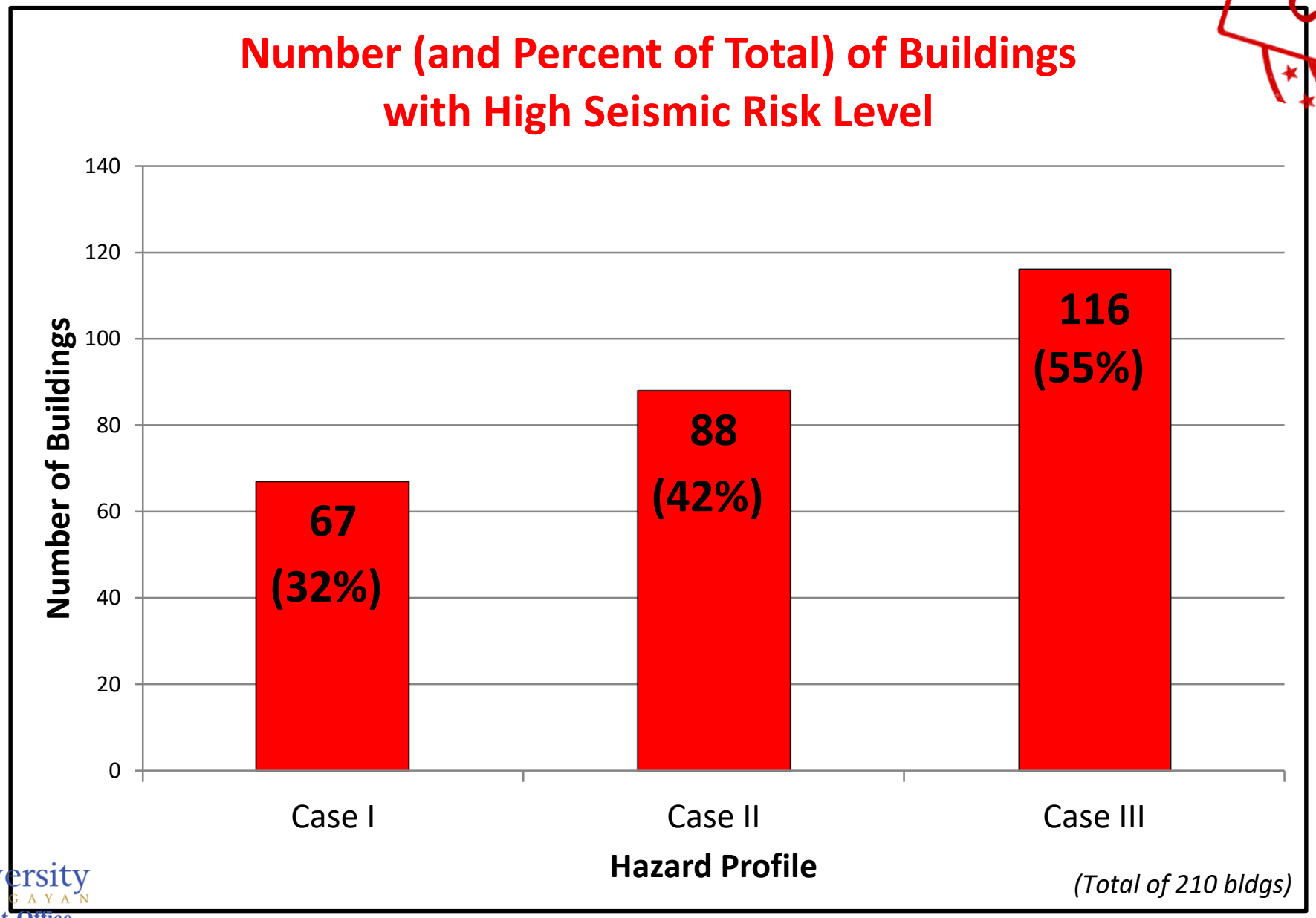
*Chan, et al (2015)*

# Number of Buildings with High Seismic Risk Level



## *Chan, et al (2015)*




Case Study

# *Chan, et al (2015) and beyond...*




**17th ASEP International Convention**
***(28-30 May 2015)***

**3rd AUN/SEED-Net Regional Conference on Natural Disasters**
***(25-26 September 2015)***

**6th Asian Conference on Earthquake Engineering**
***(22-24 September 2016)***

SCOSSO
SAFER COMMUNITIES THROUGH SAFER SCHOOLS

PRISMH
Philippines Resilience of Schools to Multi-Hazard

EPICentre

UCL

Gokongwei College of Engineering
DE LA SALLE UNIVERSITY

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Engineering and Physical Sciences Research Council

# The aim of SCOSSO is to develop an innovative, advanced, multi-hazard risk assessment framework for school infrastructures in the Philippines.

*(2016-2017)*

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PRISMH
Philippines Resilience of Schools to Multi-Hazard




**The goal of PRISMH is to investigate the effectiveness of building retrofit measures, early warning provisions and social preparedness measures as means of preventing casualties, reducing economic losses and maintaining functionality of school infrastructures and its role in the community during disasters.** *(2017-2019)*

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# OUTPUT

Contents lists available at ScienceDirect

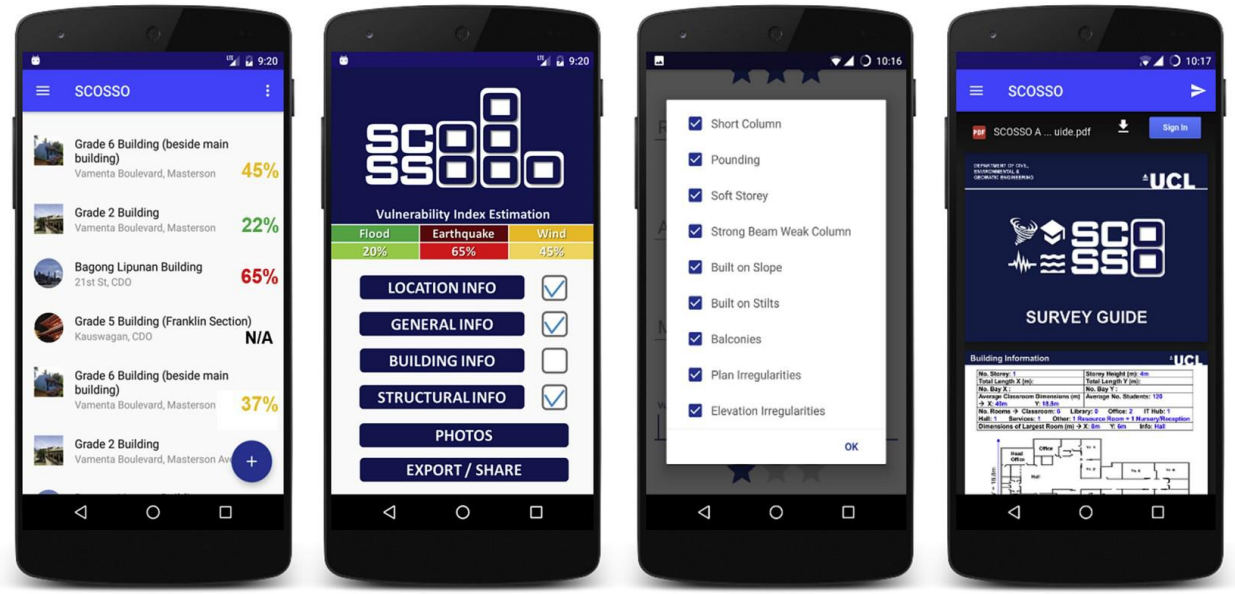
International Journal of Disaster Risk Reduction

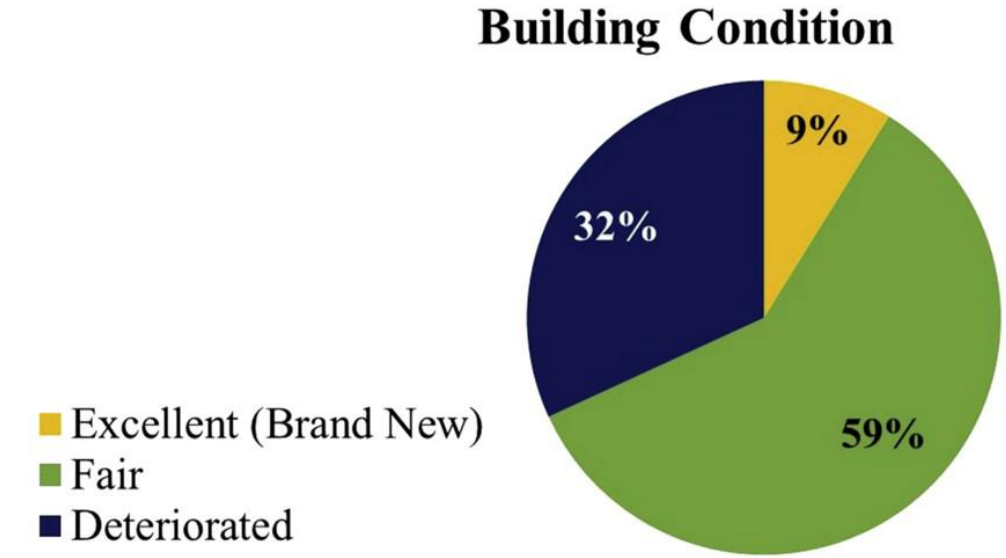
journal homepage: http://www.elsevier.com/locate/ijdrr

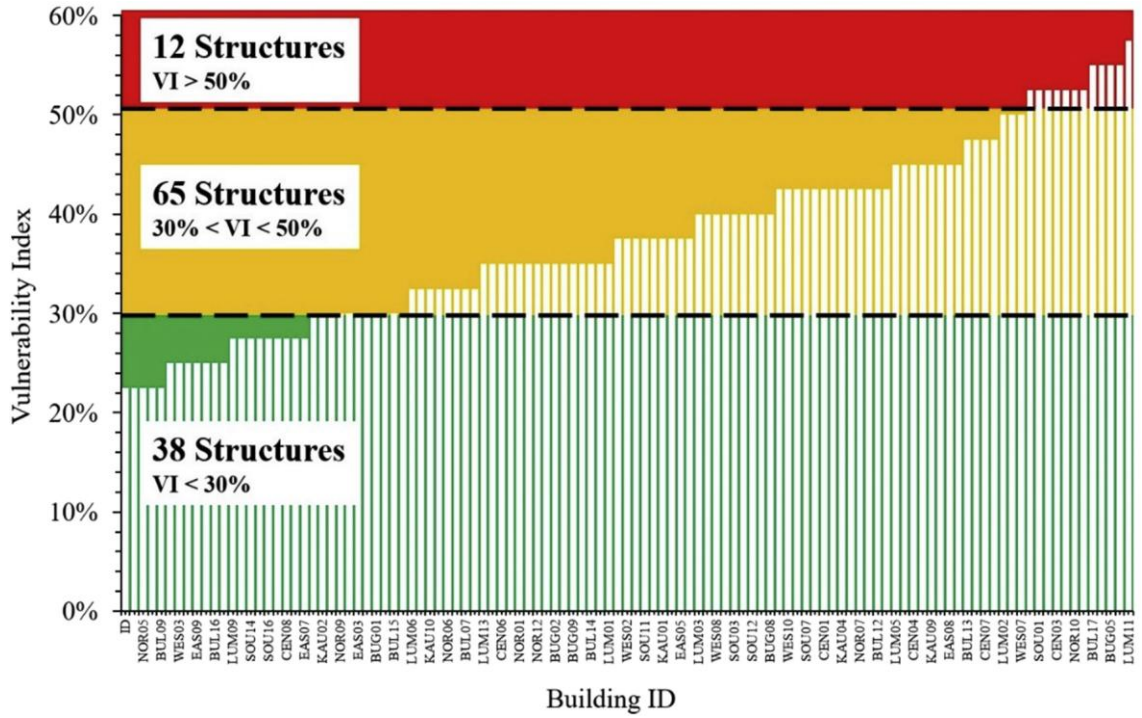
## Resilient communities through safer schools

Dina D'Ayala [a,*], Carmine Galasso [a], Arash Nassirpour [a], Rohit Kumar Adhikari [a], Luis Yamin [b], Rafael Fernandez [b], Dexter Lo [c], Lessandro Garciano [d], Andres Oreta [d]

[a] EPICentre, University College London, UK
[b] Universidad de los Andes, Bogotá, Colombia
[c] Xavier University, Cagayan de Oro, Philippines
[d] De La Salle University, Manila, Philippines

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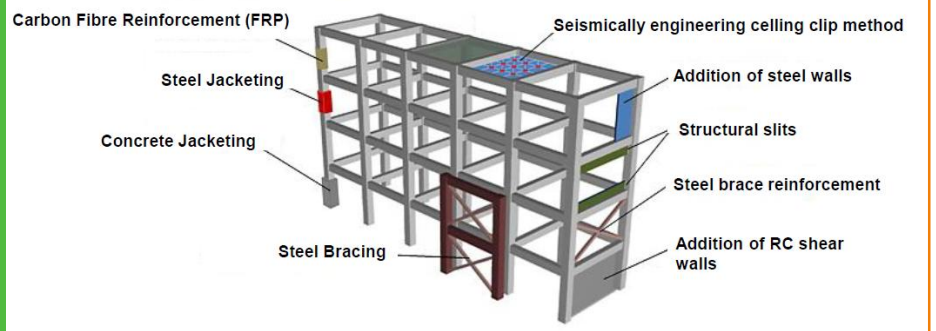



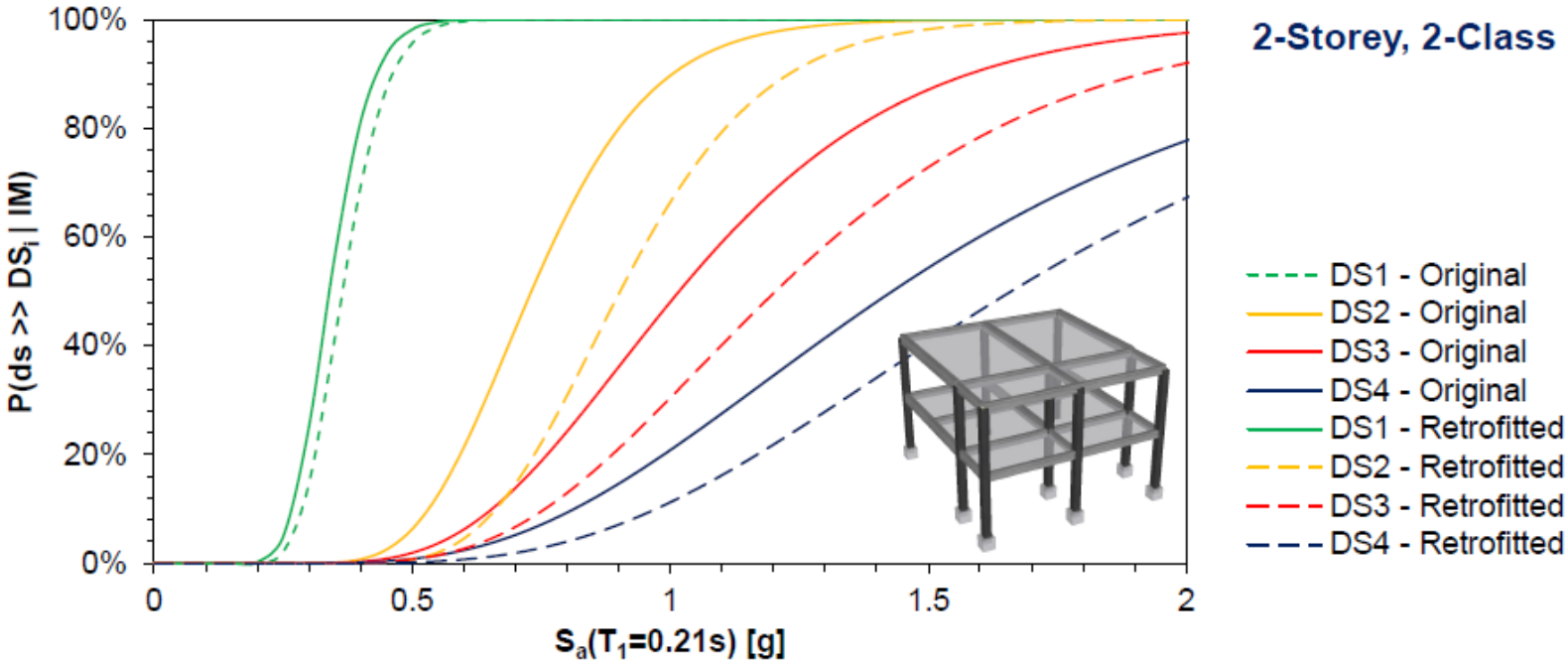


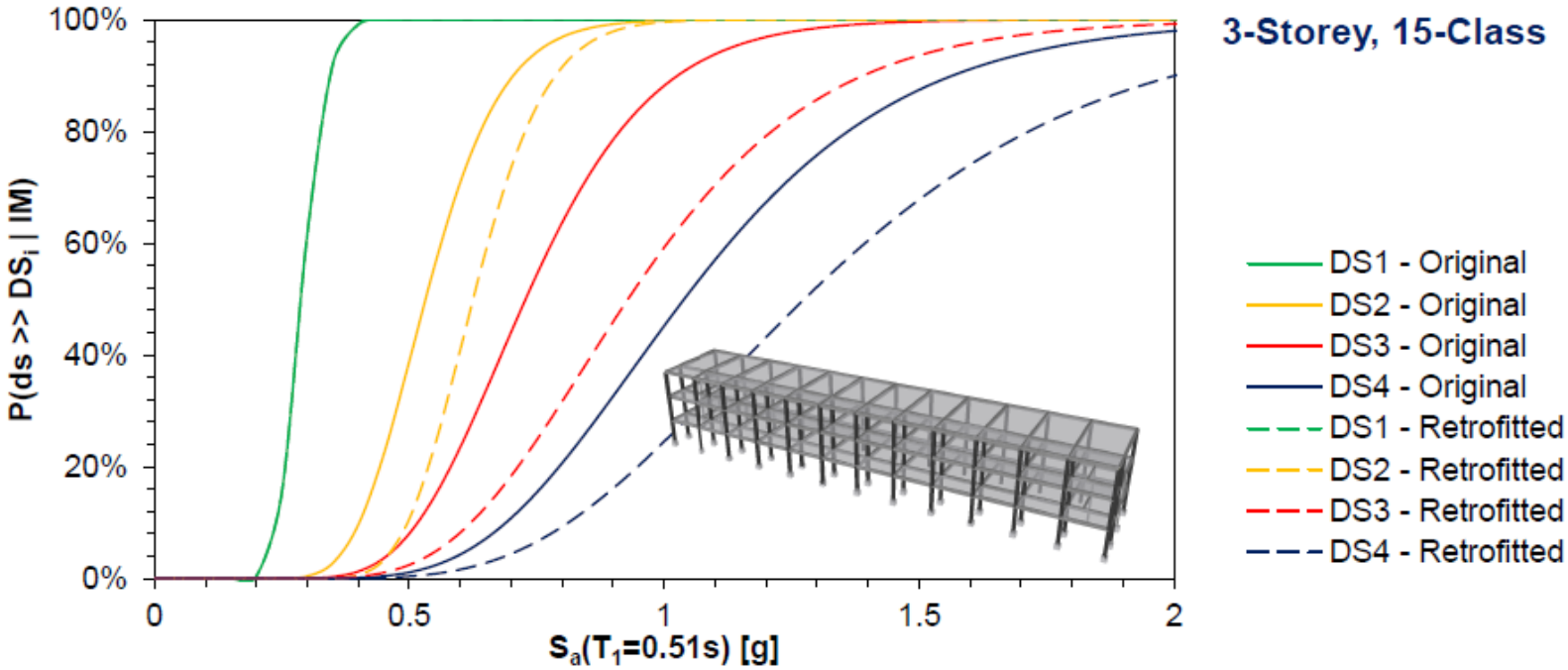


Fragility curves for different performance levels (OP – Operational, IO – Immediate Occupancy, LS – Life Safety and CP – Collapse Prevention)

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# Congratulations

## *Dexter Sumaylo Lo*

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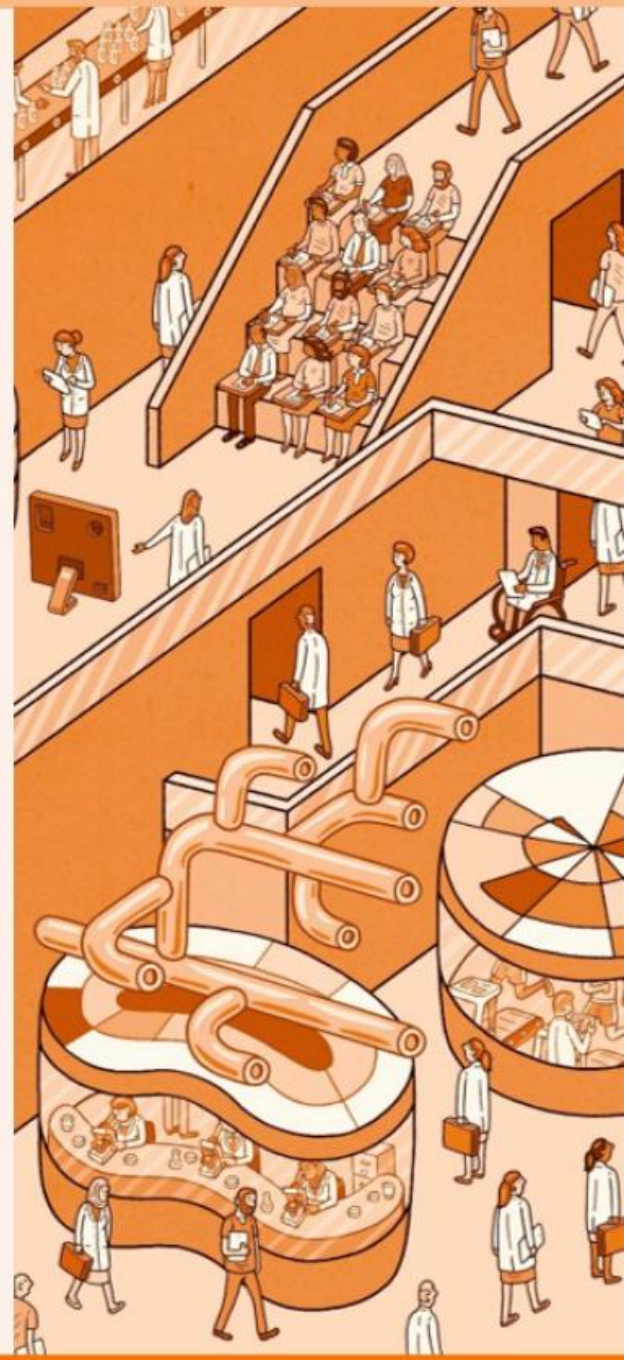
Your article was linked to the United Nations Sustainable Development Goals, helping to tackle some of the world's greatest challenges.

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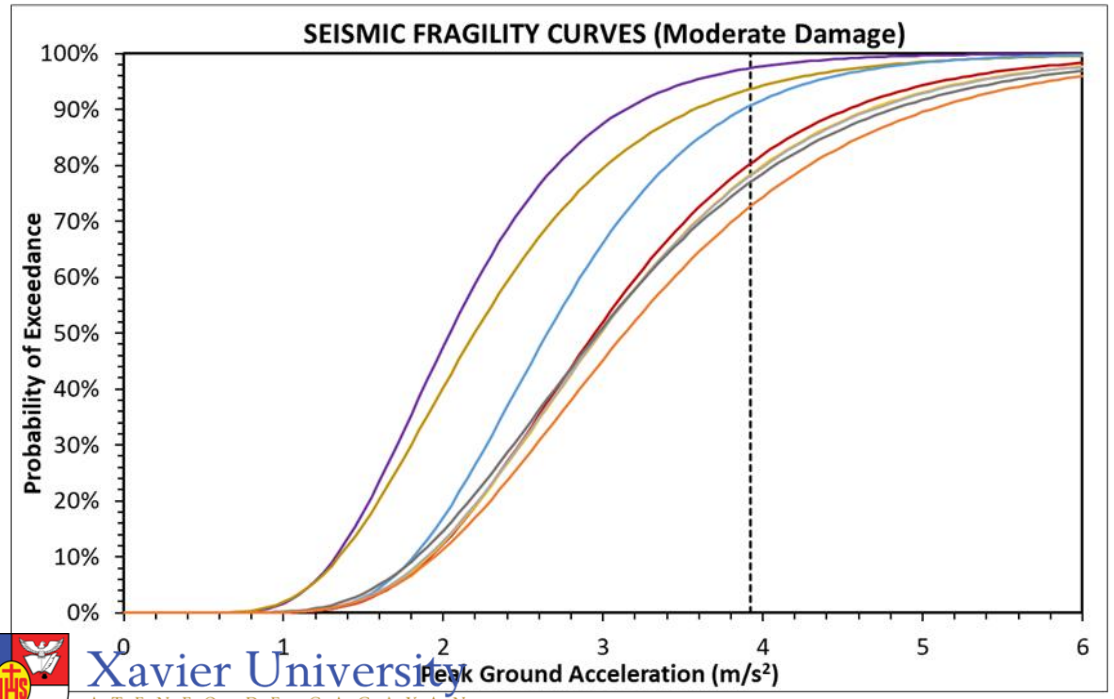
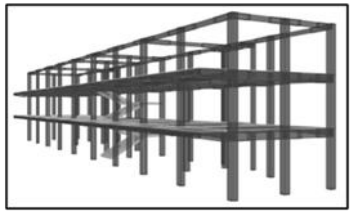
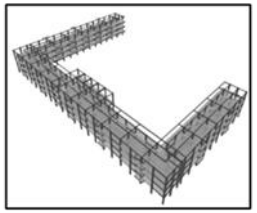
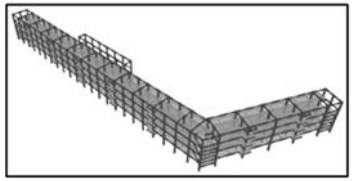
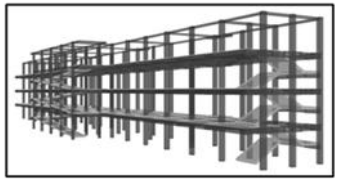
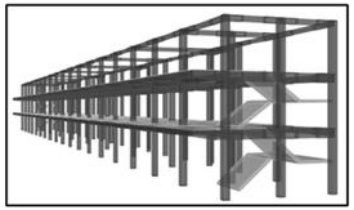
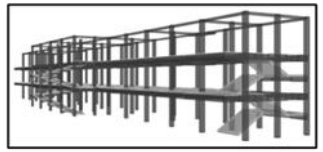
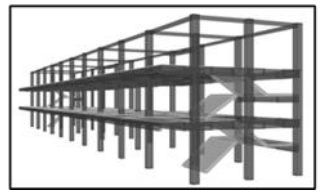
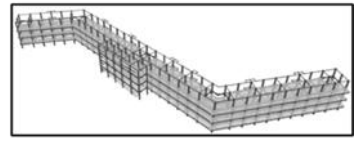
| Moderate Damage |
|---|
| Cracking in most beams and columns |
| Some yielding in a limited number |
| Limited concrete spalling |

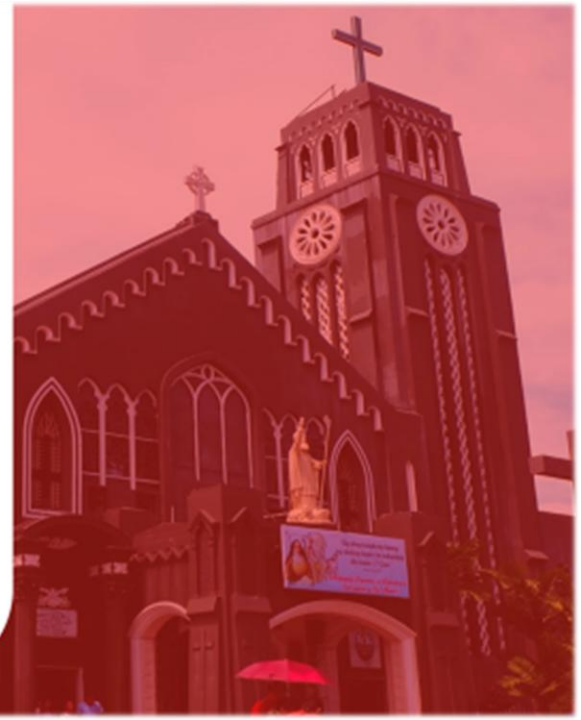



| High School | Moderate Damage (%) |
|---|---|
| Building 8 | 98 |
| Building 7 | 94 |
| Building 2 | 92 |
| Building 5 | 81 |
| Building 1 | 79 |
| Building 4 | 79 |
| Building 6 | 78 |
| Building 3 | 74 |

# Seismic Fragility Assessment of the Saint Augustine Metropolitan Cathedral in Cagayan de Oro City

Kirby F. Bonita
Kenneth Ian Jules T. Decano
Kenji Angel Matthew L. Paderanga
William Rex B. Salingay
Engr. Dexter S. Lo



# Flood and Seismic Fragility Curve Analysis of Kagay-an Bridge in Cagayan de Oro City

Amores, Nikki Gay Louise T
Cabanaz, Isaiah Alisteir S
Cupay, Garnelo Jose A
Legaspi, Alexander Christian D
Legaspi, Paul Gilbert R

Advisers:
Engr. Dexter S **LO**
Engr. Michael B **BAYLON**
Dr. Gerardo P **APOR**

# SEISMIC FRAGILITY ASSESSMENT OF THE J.R. BORJA GENERAL HOSPITAL IN CAGAYAN DE ORO CITY

CABARDO · CHING · DELORIA III · MORALES · ROMULO

ENGR. DEXTER S. LO, MSCE

# SEISMIC FRAGILITY ASSESSMENT OF SELECTED REINFORCED CONCRETE BUILDINGS IN XAVIER UNIVERSITY MAIN CAMPUS

Cadusale, Milky John Anthony R.
Calunsag, Leonard B.
Mawile, Kurt Allen C.
Rabusa, Leigh Anne Dave S.
Simon, Roven M.

MENTOR: Engr. Dexter S. Lo

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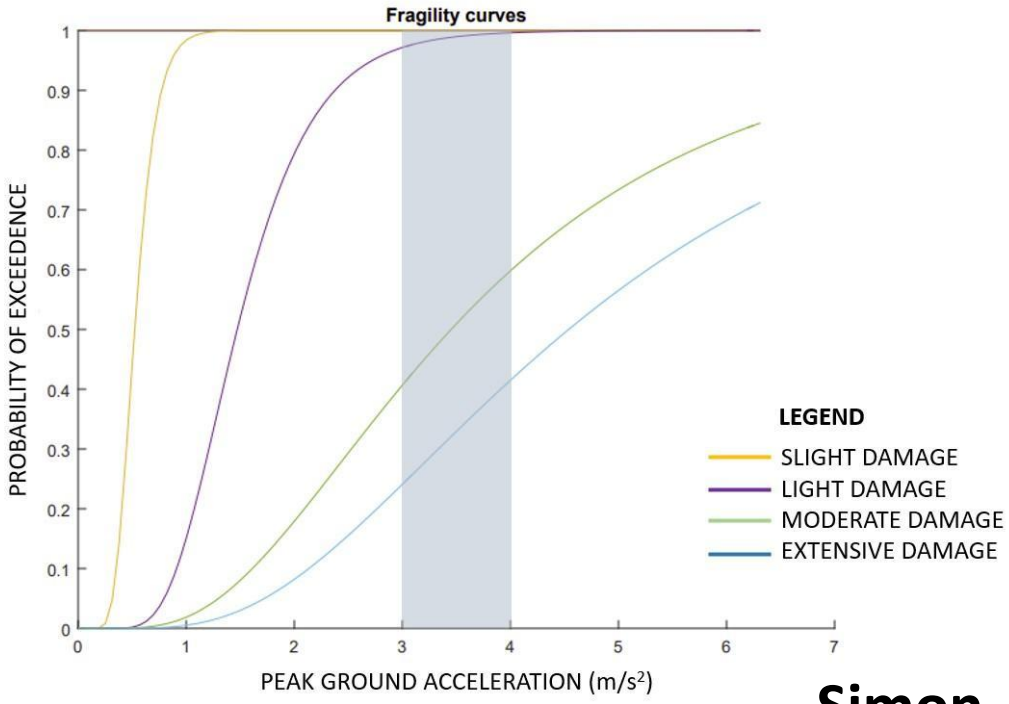
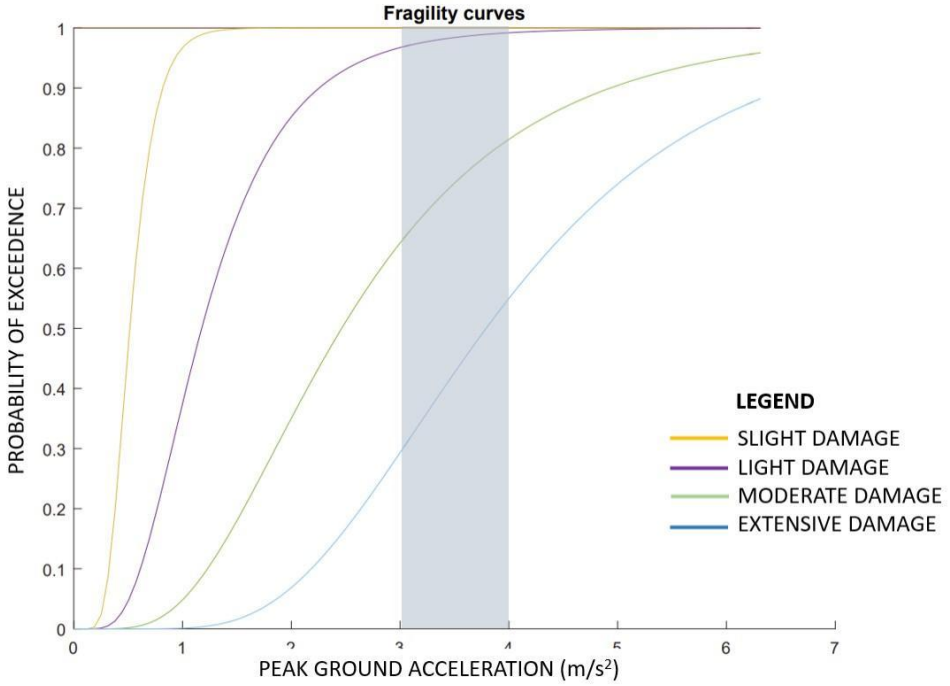
ORIGINAL

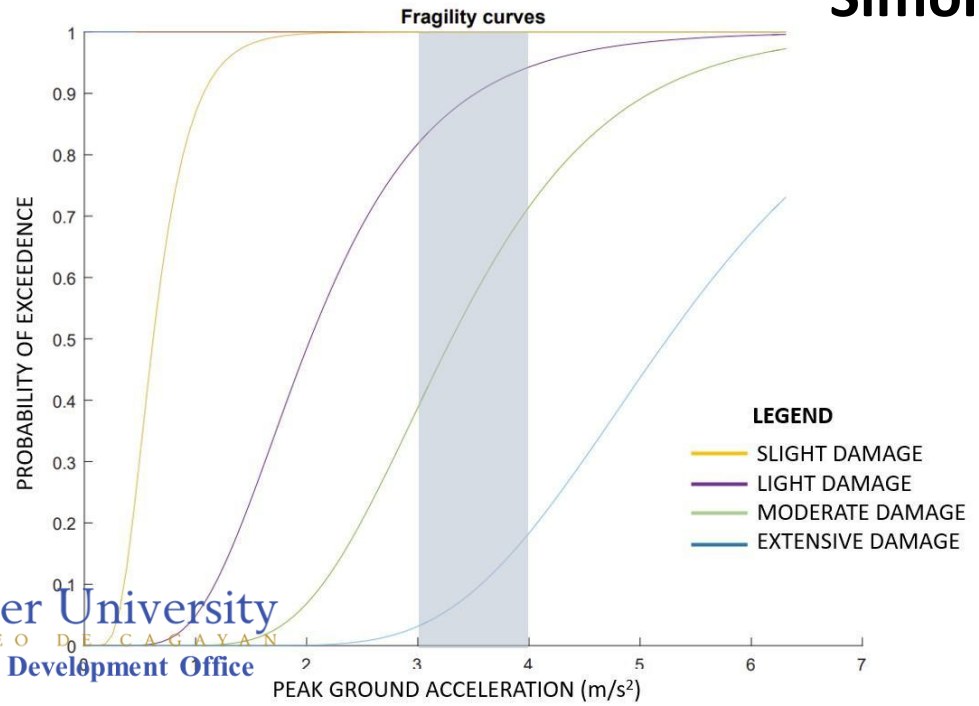



+50mm randomly: beams & columns

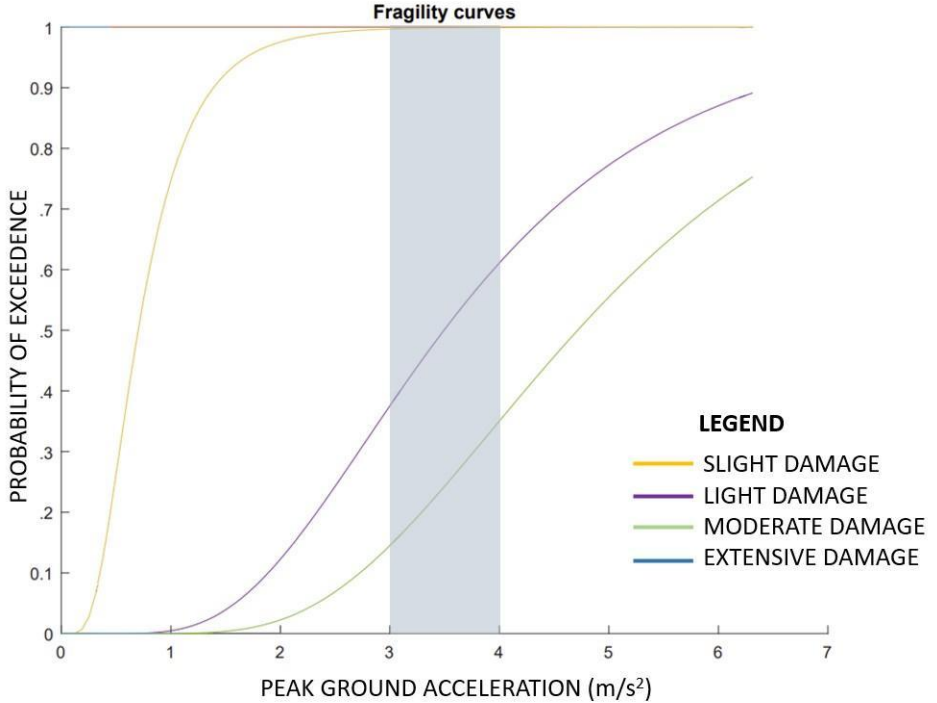



**Simon, et al (2023)**

+50mm on critical columns




+75mm on critical columns



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unesco University Chair

UCL

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## in Disaster Risk Reduction and Resilience Engineering

will create a research network and a shared knowledge, which promotes a shift in approach to school safety from individual building to local and regional school infrastructure, including the critical lifelines that make schools functional. *(2021-...)*

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# ➢ Resilience of education infrastructure

School buildings  Community  Transportation



- ➢ Performance assessment of the system
- ➢ Decision-making for optimal recovery

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# ➢ Resilience of education infrastructure

School buildings  Community  Transportation

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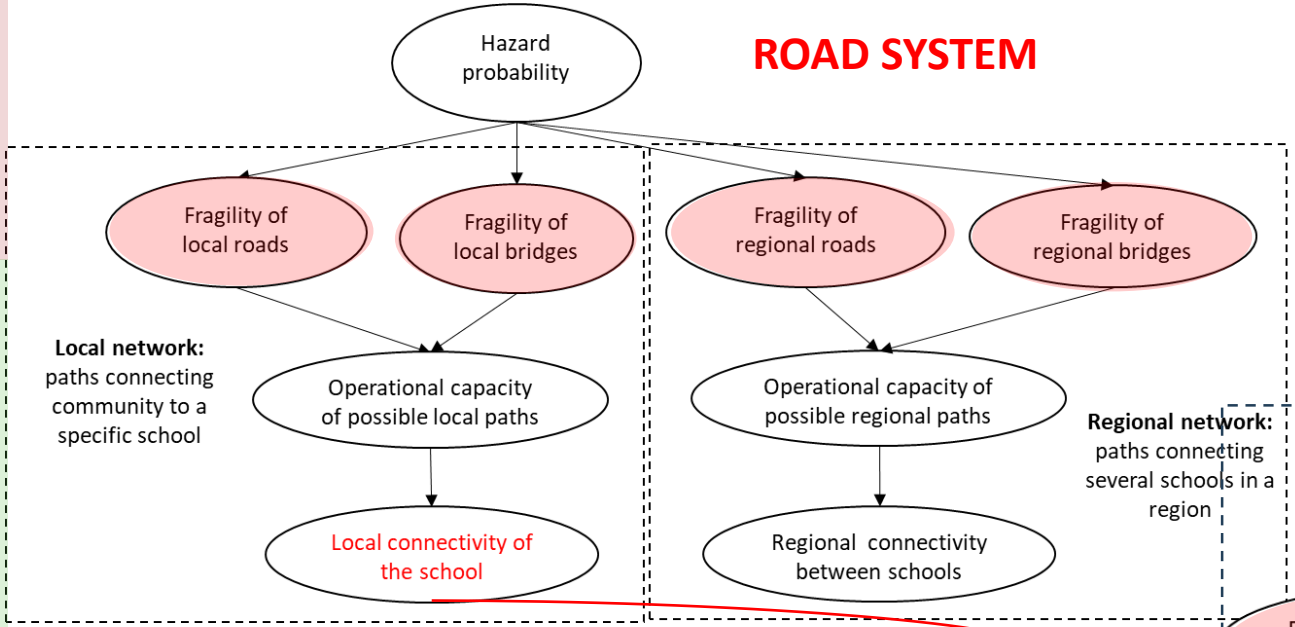
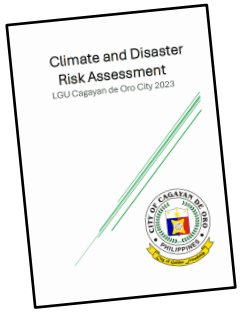
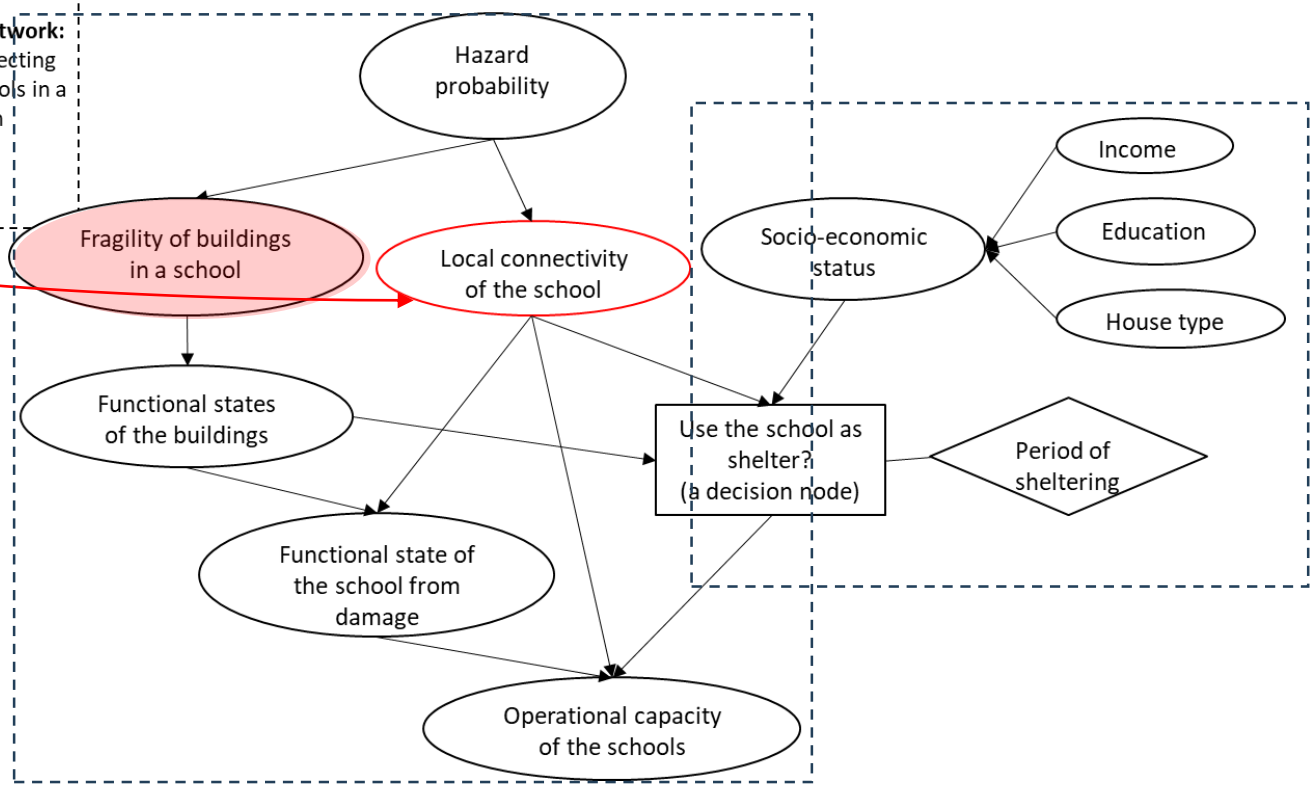



SOCIAL SYSTEM




- ✓ Estimate the states of operational capacity of schools and bridges due to structural and non-structural damage
- ✓ Estimate the state of operational capacity of school due to shelter function

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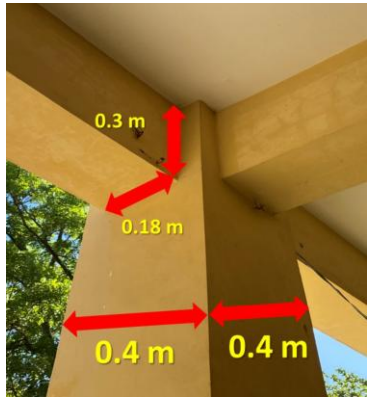
# GLOSI Taxonomy for Seismic Vulnerability Assessment

- Global Program for Safer Schools (GPSS): Initiative by the World Bank.
- The Global Library of School Infrastructure (GLOSI) taxonomy classifies school buildings based on 12 parameters.
- 3 primary and 9 secondary parameters.
- Output of the taxonomy is a building's string of attributes related to each parameter
- The taxonomy string can be seen as the building's DNA.

UNESCO Chair GLOSI Course

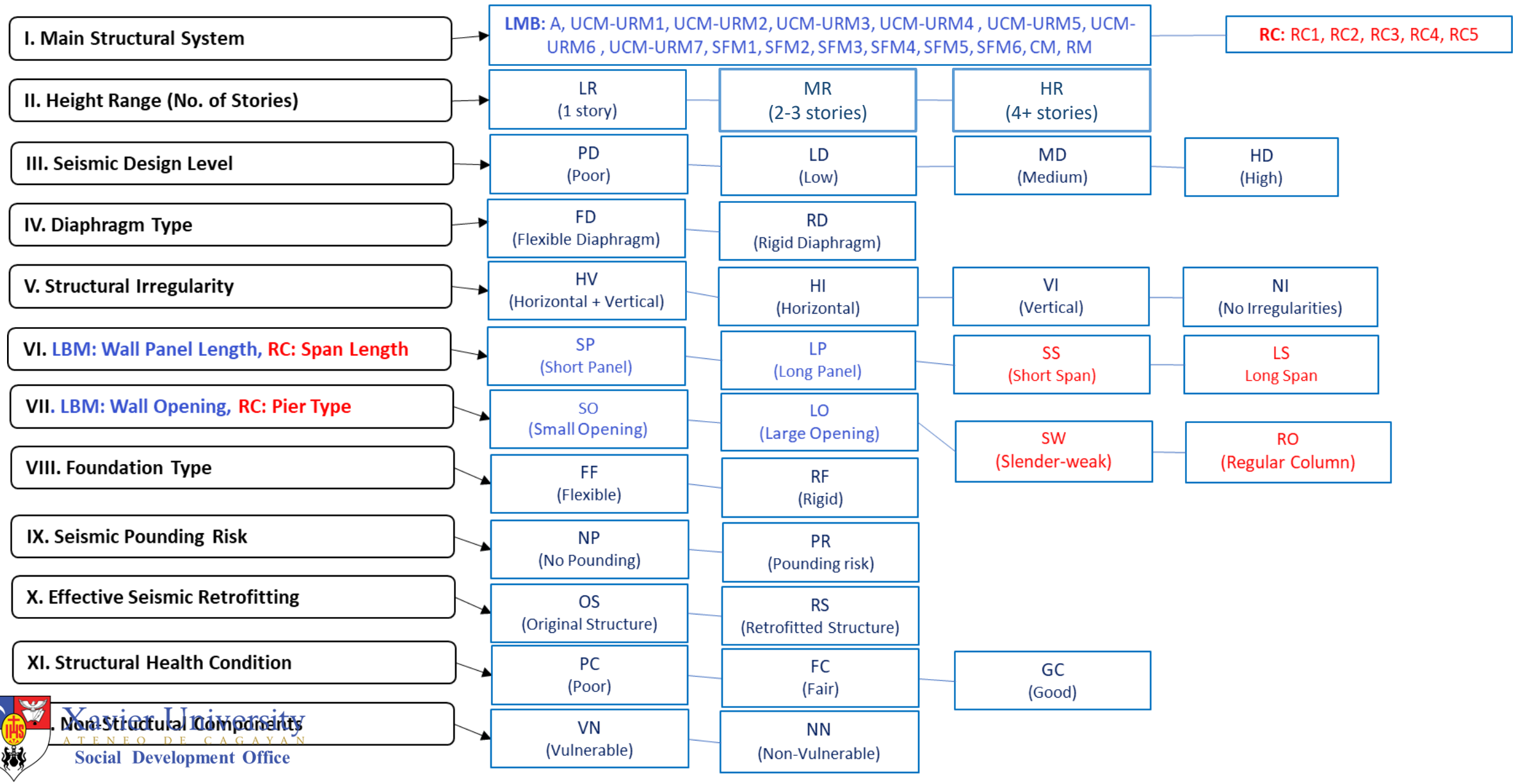




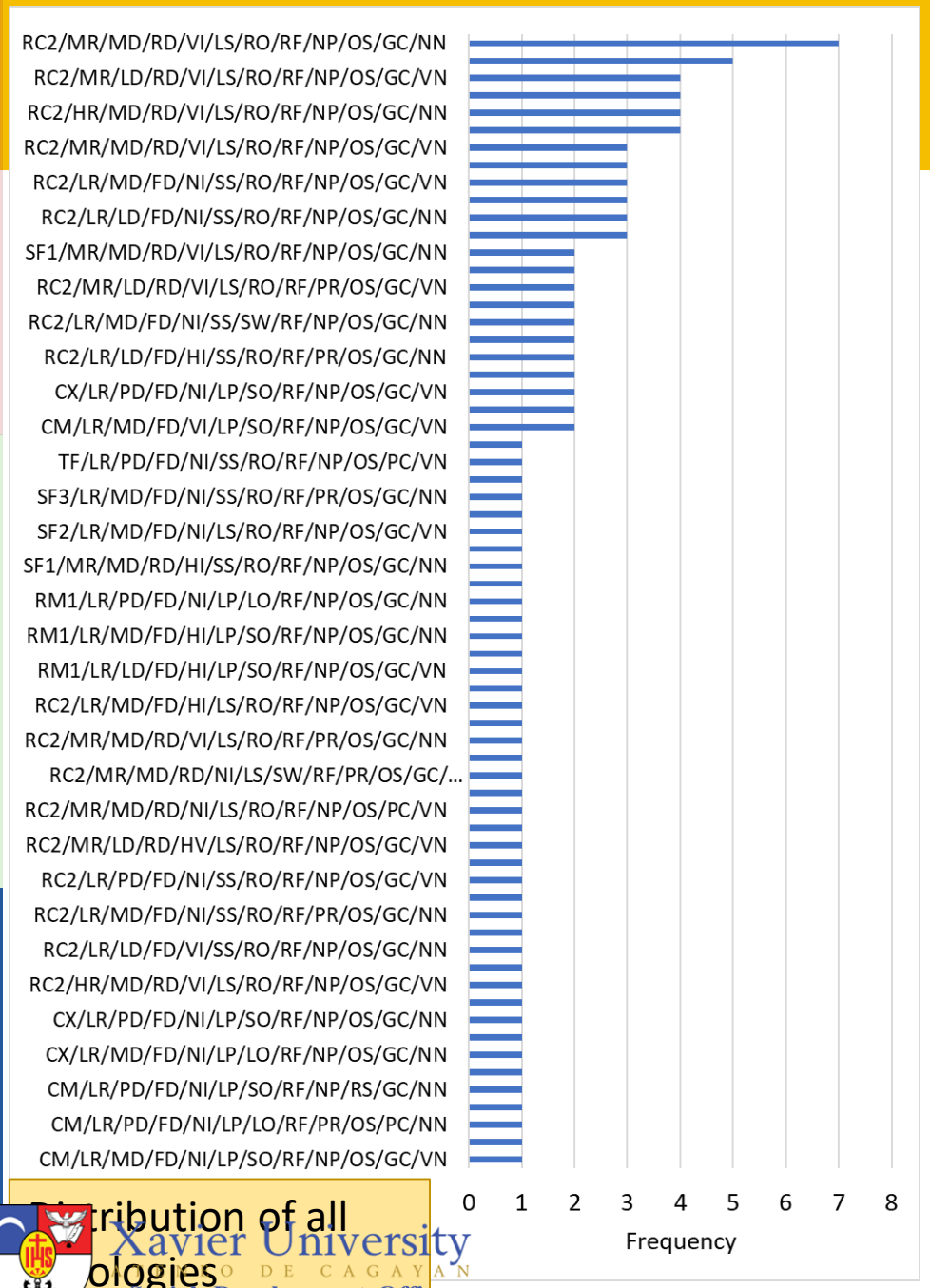




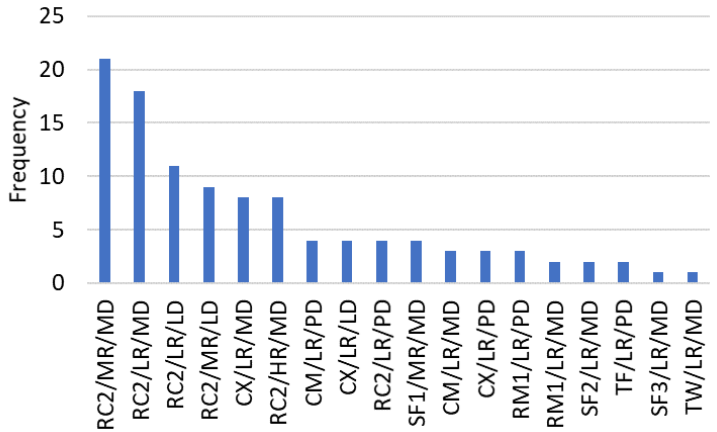
# GLOSI Taxonomy Parameters and their Attributes



# GLOSI Typologies




Distribution of all typologies

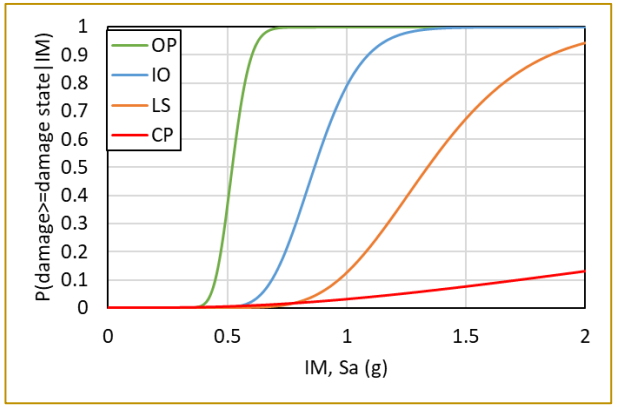


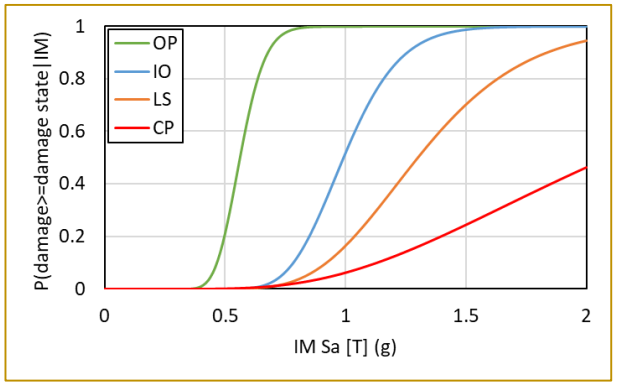

Distribution of typologies according to primary parameters


RC2/MR/MD


RC2/LR/MD

## Fragility functions

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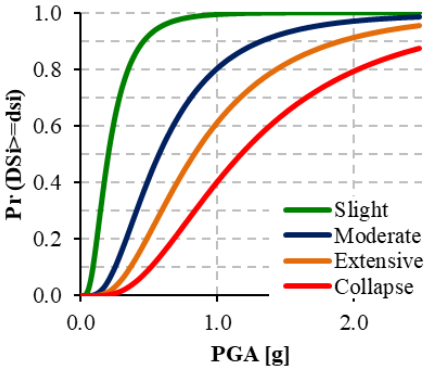
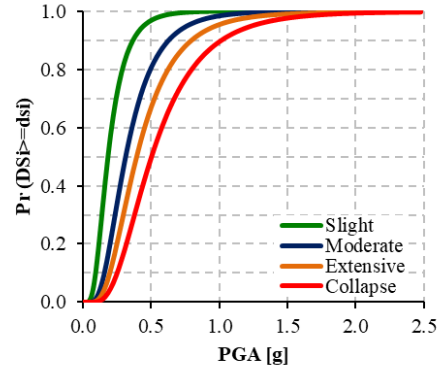
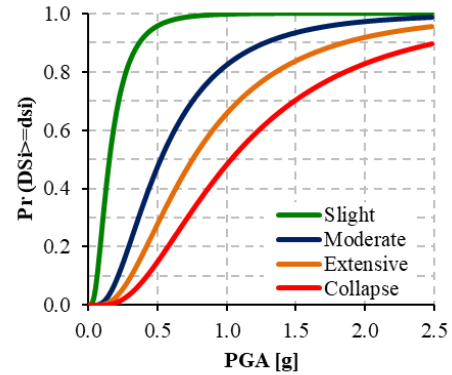
# Typology of transportation infrastructure elements

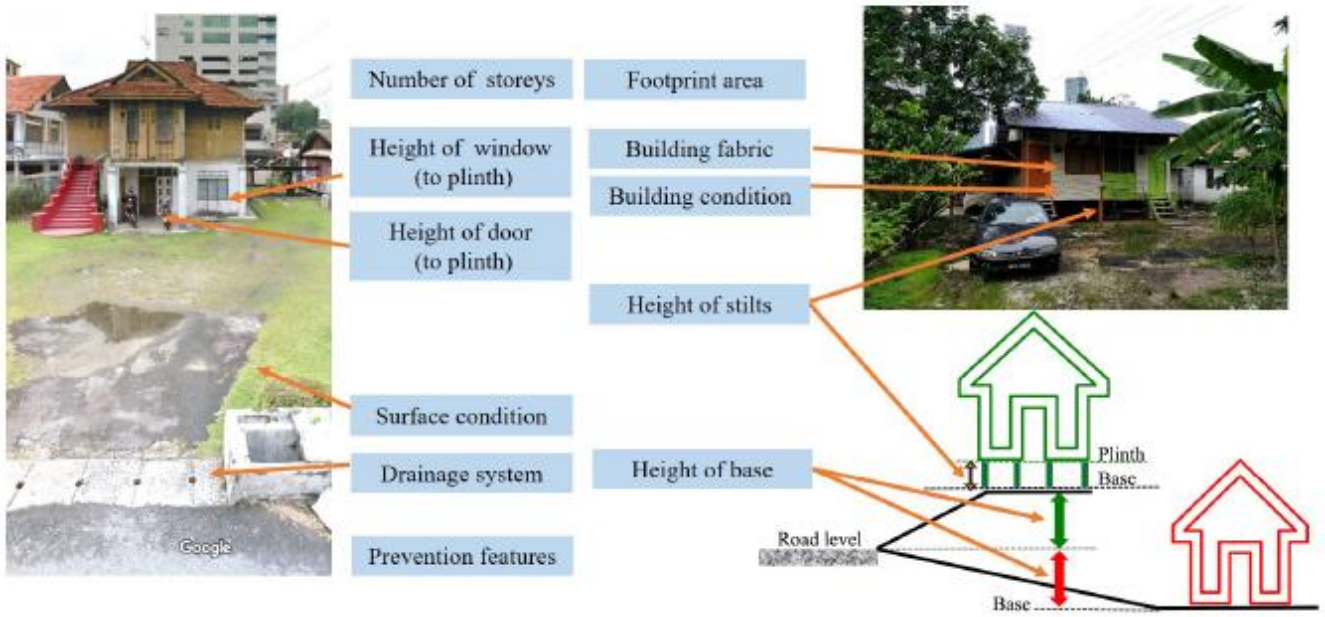
| Structure | Typology |
|---|---|
| NMMC-Gaisano Overpass | Single span concrete girder |
| Masterson Overpass | Single span concrete girder |
| Lapasan Overpass | Single span concrete girder |
| Ilaya Overpass | Single span concrete girder |
| Gateway-USTP Overpass | Single span steel girder |
| Centrio-Gaisano Mall Overpass | Single span steel girder |
| Maharilka Flyover | Multi span simply supported concrete girder |
| Macanhan Flyover | Multi span simply supported concrete girder |
| Ysalina Bridge | Multi span continuous steel girder |
| JR Borja Bridge | Multi span continuous steel girder |
| Balulang-Macasandig Bridge | Multi Span simply supported concrete girder |
| Puntod-Kauswagan Bridge | Multi span simply supported concrete girder |
| Pelaez Bridge | Multi span simply supported concrete girder |
| Maharilka Bridge | Multi span simply supported concrete box girder |
| Bonbon-Macabalan Bridge | Multi span simply supported concrete box girder* |
| Kagay-an Bridge | Multi span simply supported concrete girder |



# PARNASSUS Approach for Flood Vulnerability Assessment




Indication of vulnerability index parameters (D'Ayala et al. 2020)

| School Compound: | Lumbia Central School | | | Building ID | LUM29 | | |
|---|---|---|---|---|---|---|---|
| Latitude | 8.3982452406356192 | | | Elevation (m) | 159 m | | |
| Longitude | 124.59825588685899 | | | | | | |
| Parameter | Possible outcome | VR | | Parameters | Sub-parameter | Possible outcome | VR |
| Number of storey | 4 | 100 | | Surface condition (total VR/3) | vegetation | no | 100 |
| | 3 | 70 | | | | poor | 55 |
| | 2 | 40 | | | | good | 10 |
| | 1 | 10 | | | inclination | down | 100 |
| Footprint area ($m^2$) | fp>640 | 100 | | | | no | 55 |
| | 400<fp<640 | 77.5 | | | | up | 10 |
| | 255<fp<400 | 55 | | | permeability | no | 100 |
| | 137<fp<255 | 22.5 | | | | poor | 55 |
| | fp<137 | 10 | | | | good | 10 |
| | | | | | | | |
| Roof height | rh>7 | 100 | | Building fabric | frame material | timber | 100 |
| | 4.4<rh<7 | 77.5 | | | | masonry | 55 |
| | 3.3<rh<4.4 | 55 | | | | concrete | 10 |
| | 2.7<rh<3.3 | 22.5 | | | wall material | timber | 100 |
| | rh<2.7 | 10 | | | | masonry | 55 |
| | | | | | | concrete | 10 |
| Column at ground floor | no | 100 | | | | | |
| | yes | 10 | | Height of door threshold (m) | door to basement | 0 | 100 |
| Drainage system | no | 100 | | | | (0, 0.05] | 77.5 |
| | poor | 55 | | | | (0.05, 0.1] | 55 |
| | good | 10 | | | | (0.1, 0.23] | 22.5 |
| Prevention-to-flood-features | no | 100 | | | | (0.23, 0.3] | 10 |
| | yes | 10 | | Height of window (m) | window to basement | 0 | 100 |
| | | | | | | (0, 0.3] | 77.5 |
| Building condition | poor | 100 | | | | (0.3, 0.6] | 55 |
| | good | 55 | | | | (0.6, 1] | 22.5 |
| | excellent | 10 | | | | (1, 1.95] | 10 |
| External perimeter | ep>201 | 100 | | Height of plinth (m) | plinth to road | 0 | 100 |
| | 118<ep<201 | 77.5 | | | | (0, 0.15] | 77.5 |
| | 74<ep<118 | 55 | | | | (0.15, 0.4] | 55 |
| | 48<ep<74 | 22.5 | | | | (0.4, 0.6] | 22.5 |
| | ep<48 | 10 | | | | (0.6, 1] | 10 |

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# PARNASSUS

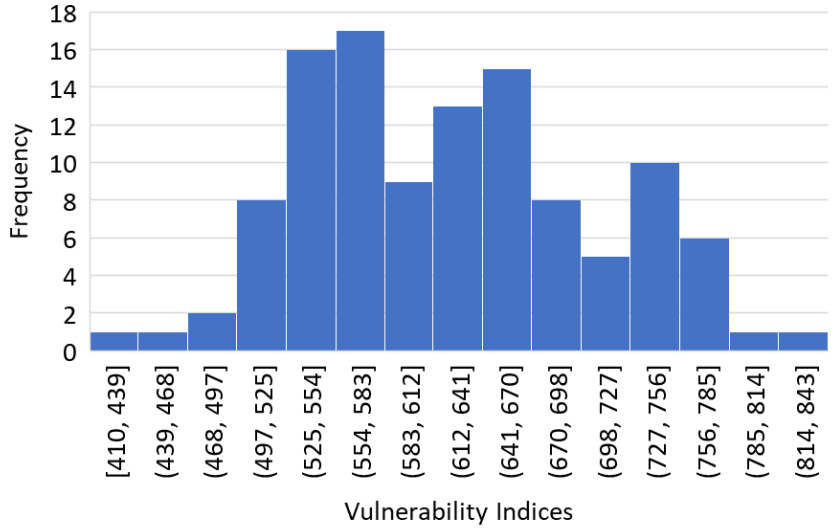
Vulnerability index of a building:

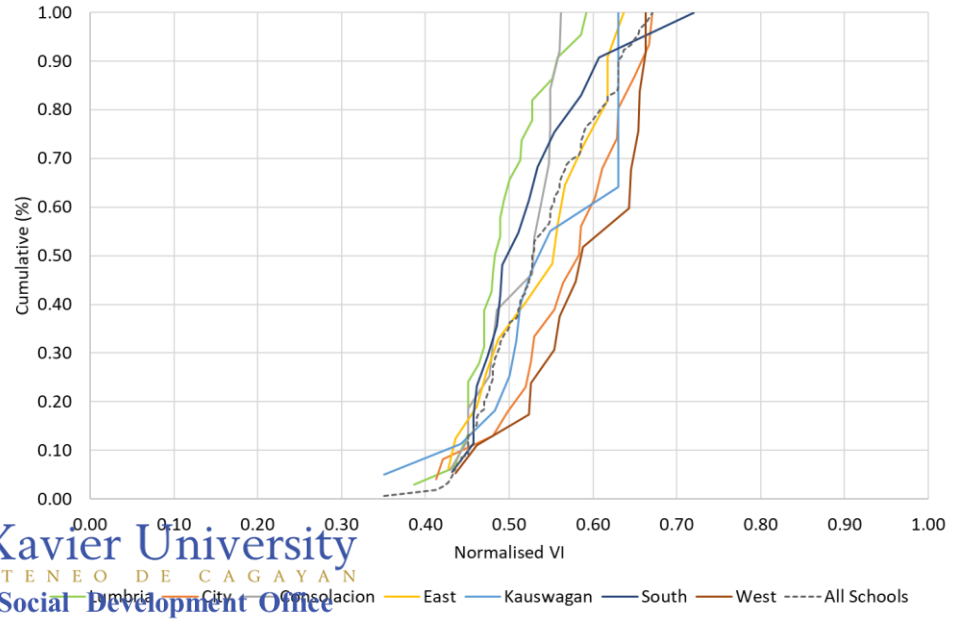
$$VI_i = \sum_j VR_{ij}$$

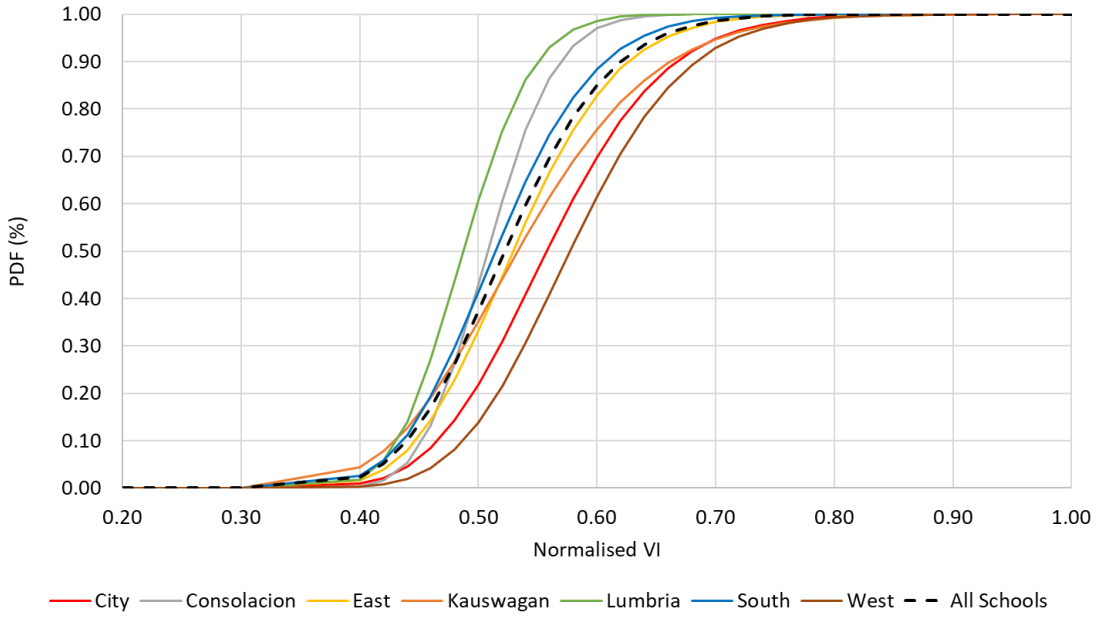
$j$: vulnerability parameter identifier
$i$: buildings identifier

Normalised vulnerability index of a building:

$$nVI_i = \frac{VI_i}{(VI_{max} - VI_{min})}$$

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## PRISMH Team Holds Stakeholder's Forum in Cagayan de Oro, Philippines

*Dexter S. Lo*

On 2nd of May 2019, a Stakeholder's Forum on Safe and Resilient Schools under the PRISMH Project was held in Xavier University, Cagayan de Oro City. The Philippines Resilience of School Infrastructures to Multi Hazards (PRISMH) Project is a collaborative endeavour of the University College London (UCL, in the United Kingdom), the De La Salle University (DLSU, in Manila, Philippines), and Xavier University – Ateneo de Cagayan (XU, in Cagayan de Oro, Philippines). It is jointly funded by the British Council and the Commission on Higher Education of the Philippines.


**E-poster of the PRISMH Stakeholder's Forum in Cagayan de Oro**

Fifteen public school campuses in Cagayan de Oro were chosen as project sites for the PRISMH Project, thus fitting to hold the Stakeholder's Forum in the city. The forum was very well attended by public officials, the academe, the private sector, and other interested groups.

The local government's delegation was headed by no less than the city mayor, Hon. Mayor Oscar Moreno, who has built more than six hundred classroom during his six years stint as city mayor. With him are representatives from: the Office of the City Building Official, the City Engineer's Office, the City Disaster Risk Reduction and Management Department, the City Social Welfare and Development, and the Oro Trade and Investment Promotions Center. Line agencies of the national government also joined the forum, represented by the regional offices: the Department of Science and Technology, the Department of Public Works and Highways, the Mines and Geosciences Bureau of the Department of Environment and Natural Resources, the Department of Education, and the


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# *XU Secures IPUR Seed Grant with other World-Renowned Universities*

Xavier University is part recipient of the IPUR Seed Grant 2023, together with the University College London (QS No 9), the University of Glasgow (QS No 76), and the National University of Singapore (QS No 8, No 1 in Asia).

Based at the National University of Singapore (NUS), the Lloyd's Register Foundation Institute for the Public Understanding of Risk (IPUR) seeks to narrow the risk perception gap between the public and experts. The UNESCO Chair in Disaster Risk Reduction and Resilience Engineering (DRR-RE) based at University College London (UCL) led by Prof Dina D'Ayala and Dr Ahsana Parammal Vatteri, has teamed up with Dr Ji-Eun Byun at University of Glasgow (UofG), Prof Darren Chian at NUS, and Prof Dexter Lo at Xavier University (XU), to secure the IPUR Seed Grant 2023 to initiate the novel project: "Affordable and accessible decision-support tool against hazard risks for local communities in developing countries".

Xavier Ateneo is a partner of the UNESCO Chair in DRR-RE. Prof Lo has previously collaborated with Prof D'Ayala in the Philippines Resilience of Schools to Multi-Hazard (PRSIMH) Project, jointly funded by the British Council and the Commission on Higher Education of the Philippine Government.

Original article: *https://www.ucl.ac.uk/epicentre/news/2024/apr/unesc chair-secures-ipur-seed-grant-2023-collaboration-nus-uofg-and-xu*

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**Affordable and accessible decision-support tool against hazard risks for local communities in developing countries**

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SPEAKERS:

**DR. CHIAN SIAU CHEN (DARREN)**
Associate Professor, Department of Civil and Environmental Engineering
National University of Singapore

**DR. JI-EUN BYUN**
Lecturer in Smart Infrastructure
James Watt School of Engineering, University of Glasgow

**DR. AHSANA PARAMMAL VATTERI**
Research Fellow, UNESCO Chair in Disaster Risk Reduction and Resilience Engineering, University College London

**ENGR. GAIL DE LA RITA**
Director, Service-Learning Program
Xavier University - Ateneo de Cagayan

**ENGR. DEXTER S. LO**
VP for Social Development, Xavier University
Founding Director, XU Engineering Resource Center

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1. Qualitative / descriptive assessments are important. Stories matter.

2. Quantitative (engineering) assessments can offer added-value: problem-focused, solutions-driven.

3. Systems approach in social parameters, but also in physical-structural-functional parameters.

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