Current State of Global Social Vulnerability and Resilience Modelling

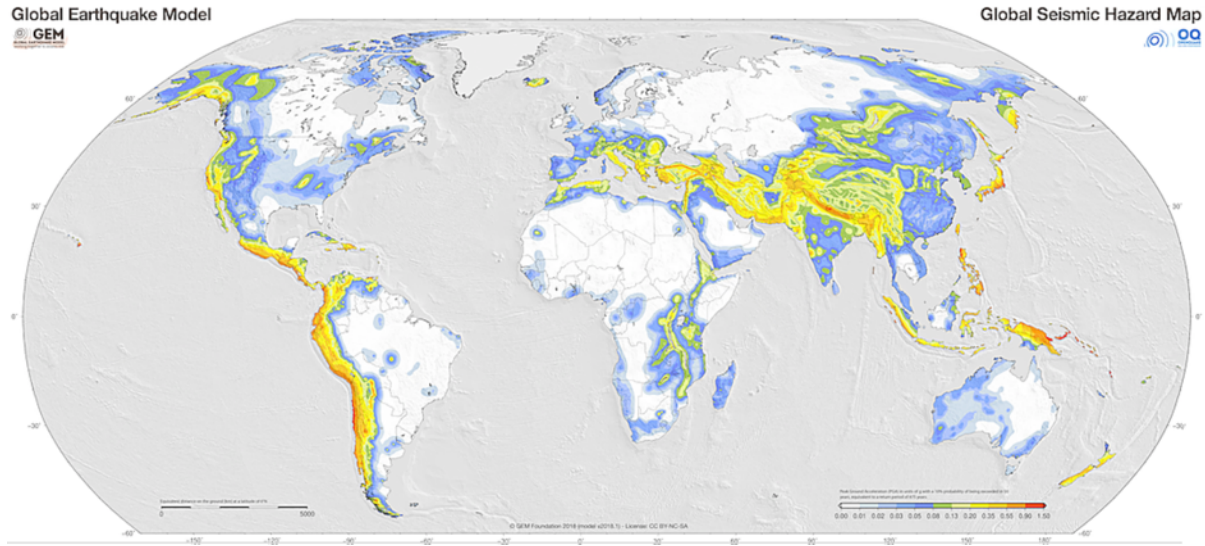Dr. Christopher G. Burton, University of Connecticut

Miguel Toquica, GEM Foundation

Khan Mortuza Bin Asad, Texas State University

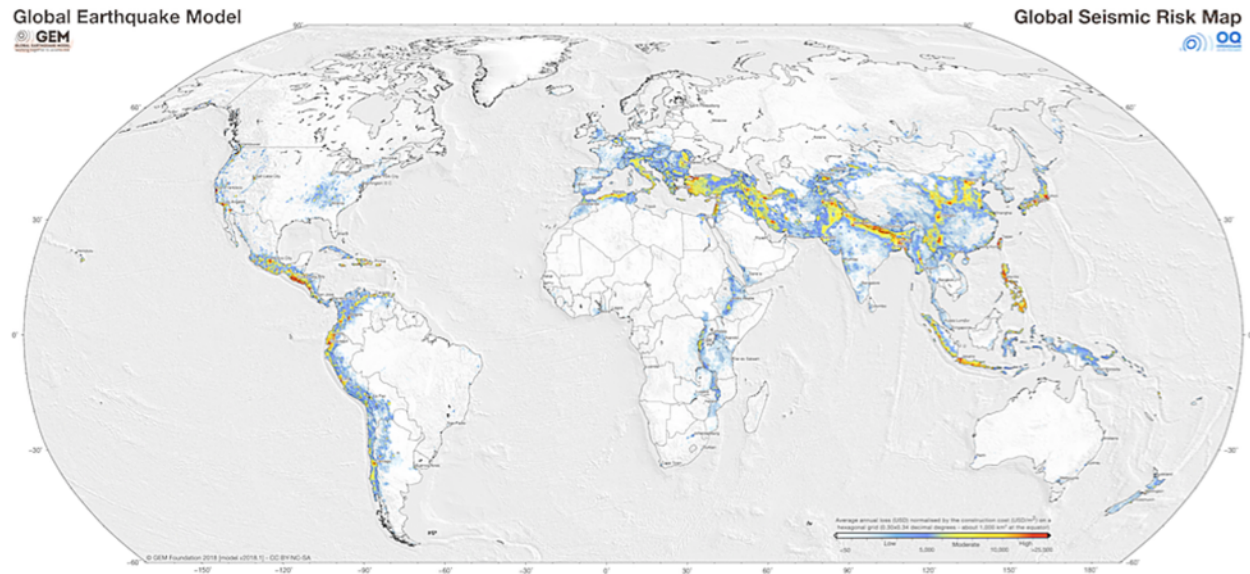Michael Musori, formerly GEM Foundation

Global Hazard Model

Pagani et al. 2018

Global Risk Model

Silva et al. 2018

Starting Point: Indicators for Measuring Societal Characteristics of Earthquake Risk

<u>Indicator</u>: measures derived from observed facts that model the reality of a complex situation

<u>Composite Index</u>: combination of individual indicators or thematic sets of indicators that represent different dimensions of a concept

Step 1. Theoretical framework
Step 2. Select indicators (Tier 1 Validation)
Step 3. Standardization/Normalization
Step 4. Multivariate analysis
Step 5. Links to other variables (Tier 2 Validation)
Step 6. Weighting and aggregation
Step 7. Robustness and sensitivity
Step 8. Presentation and dissemination

Integrated Risk Modellling toolkit

GEM
GLOBAL EARTHQUAKE MODEL
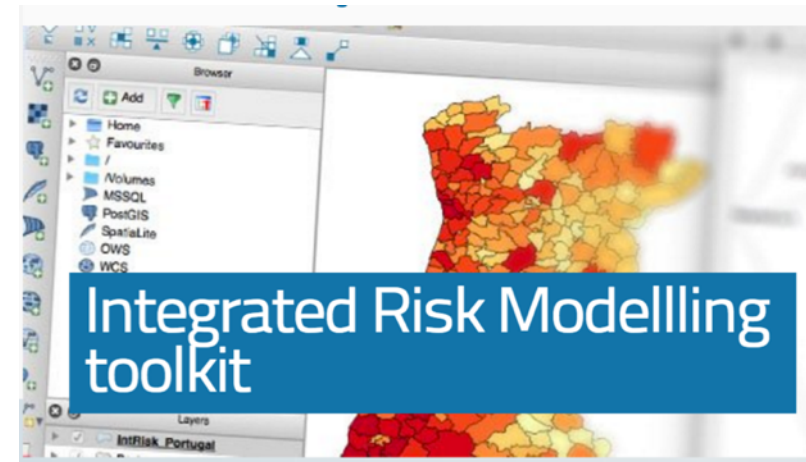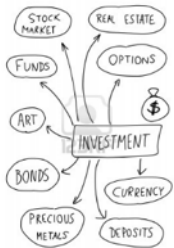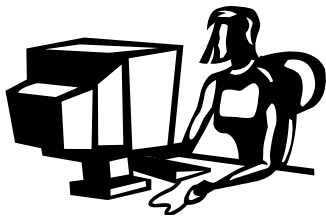
Framework for Vulnerability Assessments (Tier 1)
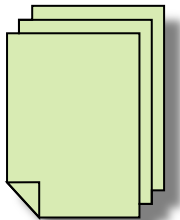
Exhaustive Literature Review

Review of 300+ vulnerability articles for taxonomy and wish list

Taxonomy Development

Social Vulnerability, Economic Vulnerability, Recovery and Reconstruction Potential

Proxy Indicator Development Based on Three Criteria

Justified in literature; Freely available; Amenable to downscaling

Widespread Data Collection

Variables collected, standardized, and assigned to respective index category for Tier 2 validation stage

UR2020

Broad Categories for Measuring Societal Characteristics of Vulnerability
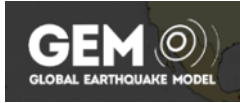
SOCIAL

- Measurement of characteristics in social systems that create potential for loss or harm
- Is essential to capture **differential capacities of populations** to reduce earthquake risk
- Focus is on proxy indicators to measure **pre-existing** social conditions that aggravate or attenuate impacts of earthquakes

ECONOMIC

- Designed to measure potential for economic losses due to the **exposure** of a country's macro-economy to exogenous shocks
- Is also an appraisal of the ability of a country to **mitigate and respond** to shocks to its economic system
- Considers **economic vitality** of populations

RECOVERY POTENTIAL

- Is closely aligned with concept of disaster resilience since resilience has been linked to **recovery** outcomes
- Also encompasses ability to reorganize, change, and learn in response to a damaging earthquake impact

Focused on countries that demonstrate at least minimal earthquake risk, i.e., seismicity >0.05 PGA and >10,000 predicted average annual losses
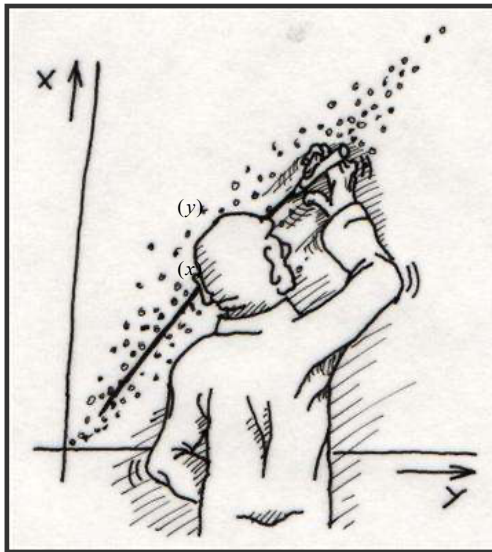
Multivariate Analysis

GEM Social Vulnerability Database
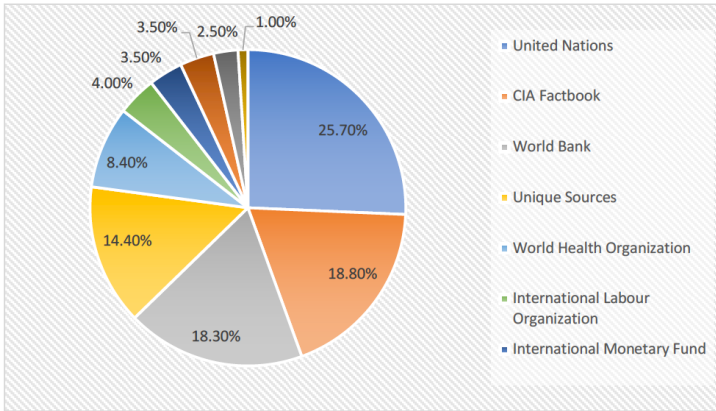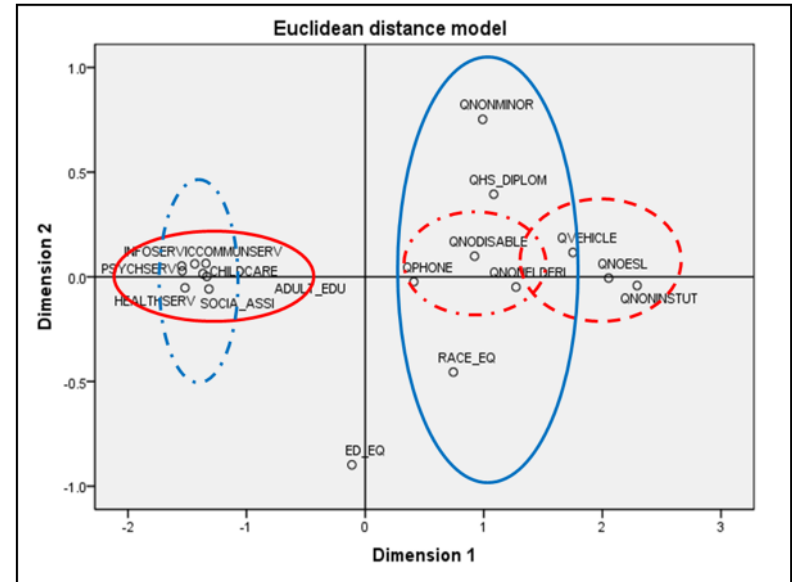

From: Power et al. 2014

- Primary step of Tier 2 Validation
- Useful to achieve parsimony— data reduced from 78 to 53 relevant indicators

Kendal's Tau Correlation

Source: www.vias.org

Multidimensional Scaling (MDS)

Approach for Final Variable Selection

Socio-economic data (as independent variables)

↓

Machine Learning and logistic regression analysis

- U.S. National Geophysical Center's Significant Earthquake Database 2008-2018
- Collected events that conformed at least one criteria: 1) had fatalities; 2) caused moderate damage (>= $1 M USD); 3) had magnitude 7.5 or greater; 4) had MMI X or greater; 5) generated a tsunami

Total losses in USD (as dependent variable)

Damaged or destroyed houses per capita (as dependent variable)

Per capita fatalities (as dependent variable)

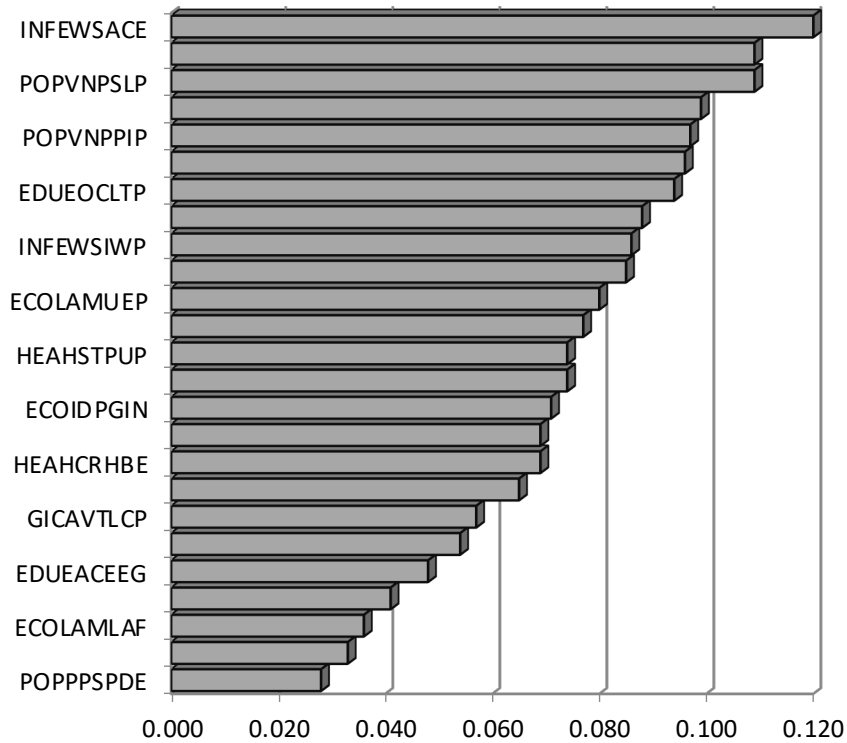**Per capita casualties (as dependent variable)**

Validated Variable Set

- 36 of 53 variables significant
- Variables assigned to respective indices based on literature and expert opinion
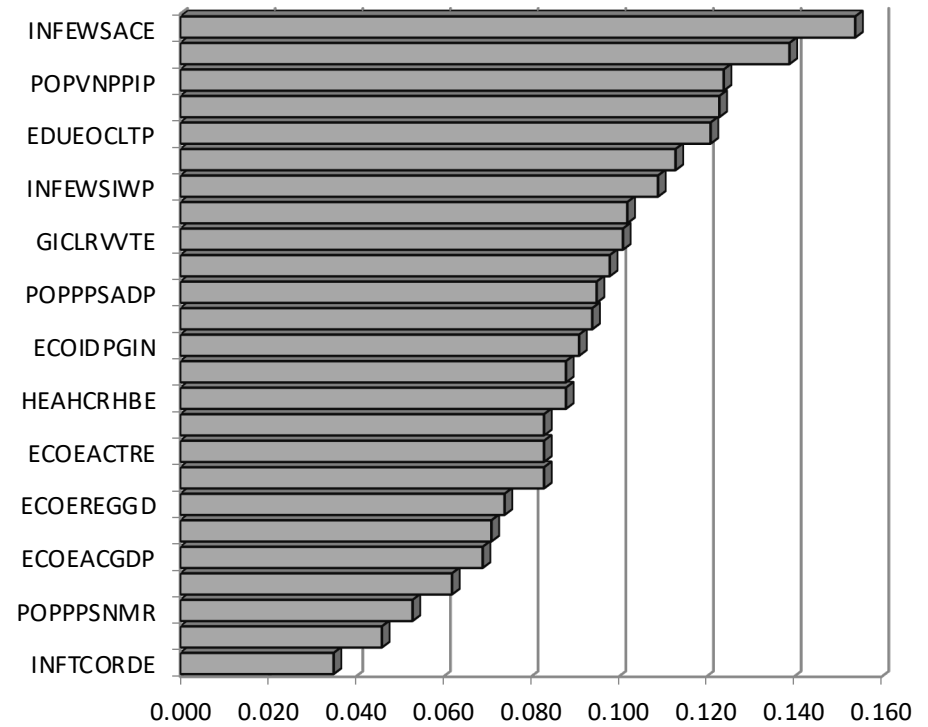- Directionality considered during aggregation

GEM GLOBAL EARTHQUAKE MODEL

Basic Sensitivity Analysis

Social Vulnerability

Recovery Potential

Social Vulnerability Index

GEM
GLOBAL EARTHQUAKE MODEL
working together to assess risk

Social Vulnerability Map

OQ
OPENQUAKE
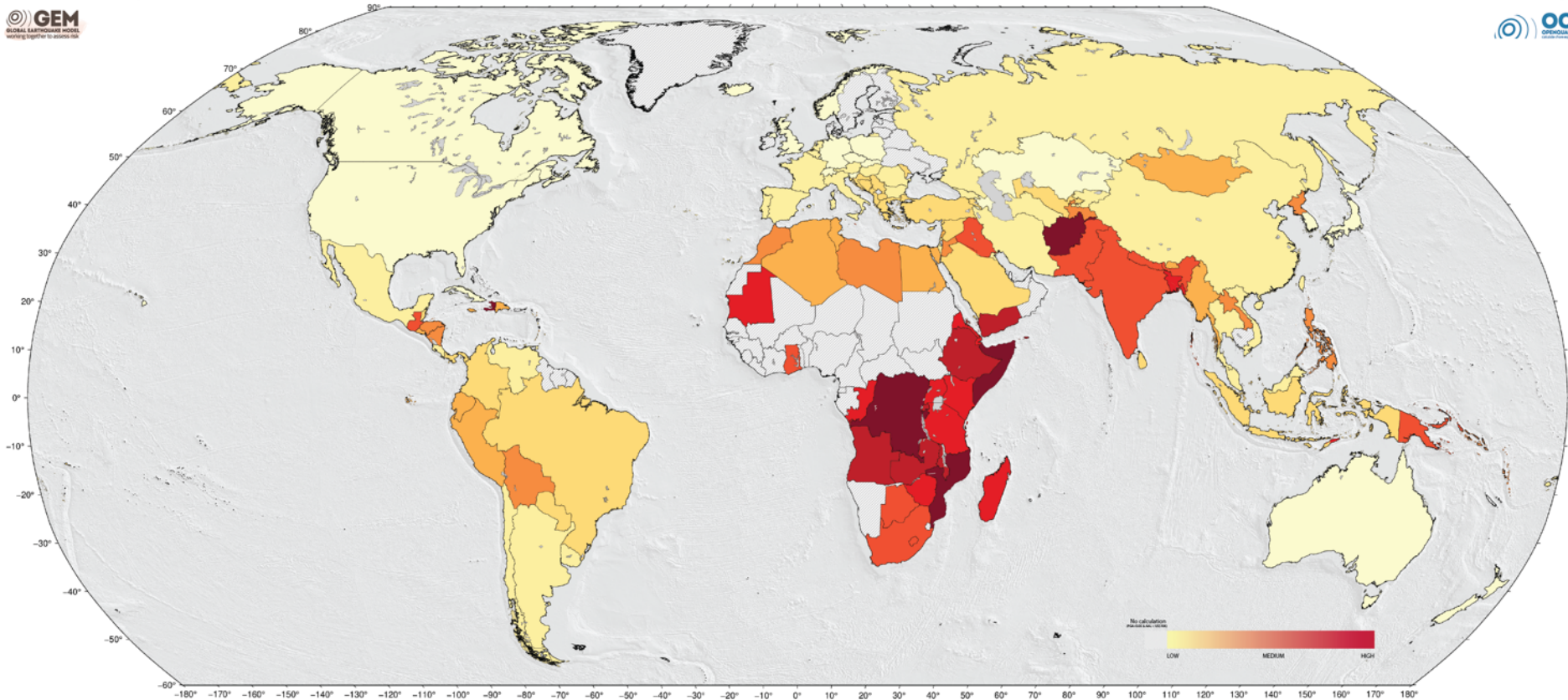
GINI Index of Equality (+)

Age Dependency Ratio (+)

% population that is a foreign-born migrant (+)

% adult labor force participation (-)

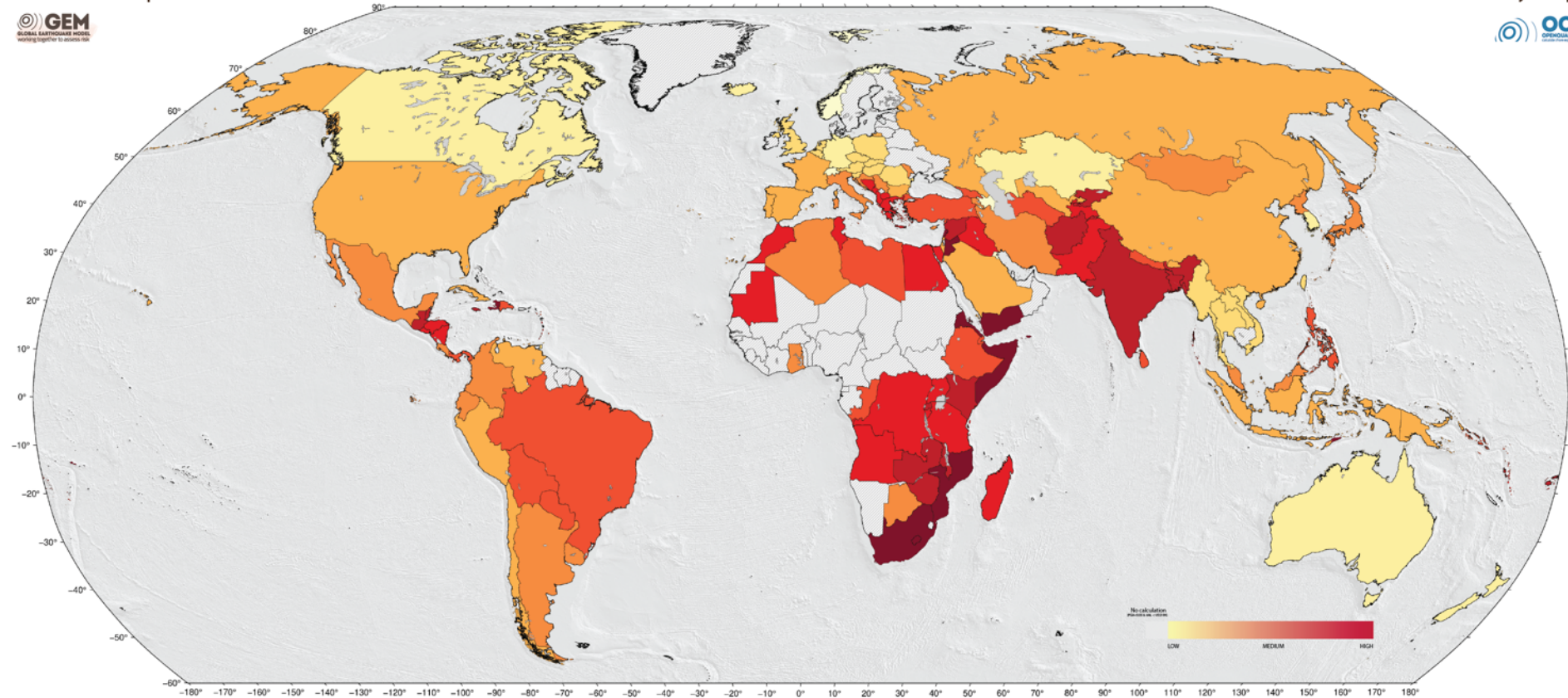Crime rate (theft, robbery, vandalism) (+)

Percent population in poverty (+)

% population with access to an improved water source (+)

Net migration rate (+)

Population density (+)

% of population living in slums (+)

Unemployment rate (+)

Building density (+)

International tourism arrivals per capita (+)

Average household size (+)

GDP per capita (-)

Crude death rate (+)

Illiteracy rate (+)

Mortality rate (under 5-years) (+)

Primary school participation rate (-)

% population that is undernourished (+)

UR2020

Economic Vulnerability Index

General government gross debt (+)	% building infrastructure that is industrial development (+)
GINI Index (+)	Total building density (+)
Age dependency ratio (+)	GDP per capita (-)
% adult labor force participation (-)	Merchandise exports FOB (+)
Gross fixed capital formation (-)	Merchandise imports CIF (+)
Unemployment rate (+)	Gross national savings (-)
Road density (-)	International tourism receipts as a percent of GDP (+)
Female labor force participation rate (-)	Percent of population in poverty (+)
% building infrastructure that is commercial development (+)	

Recovery Potential Index
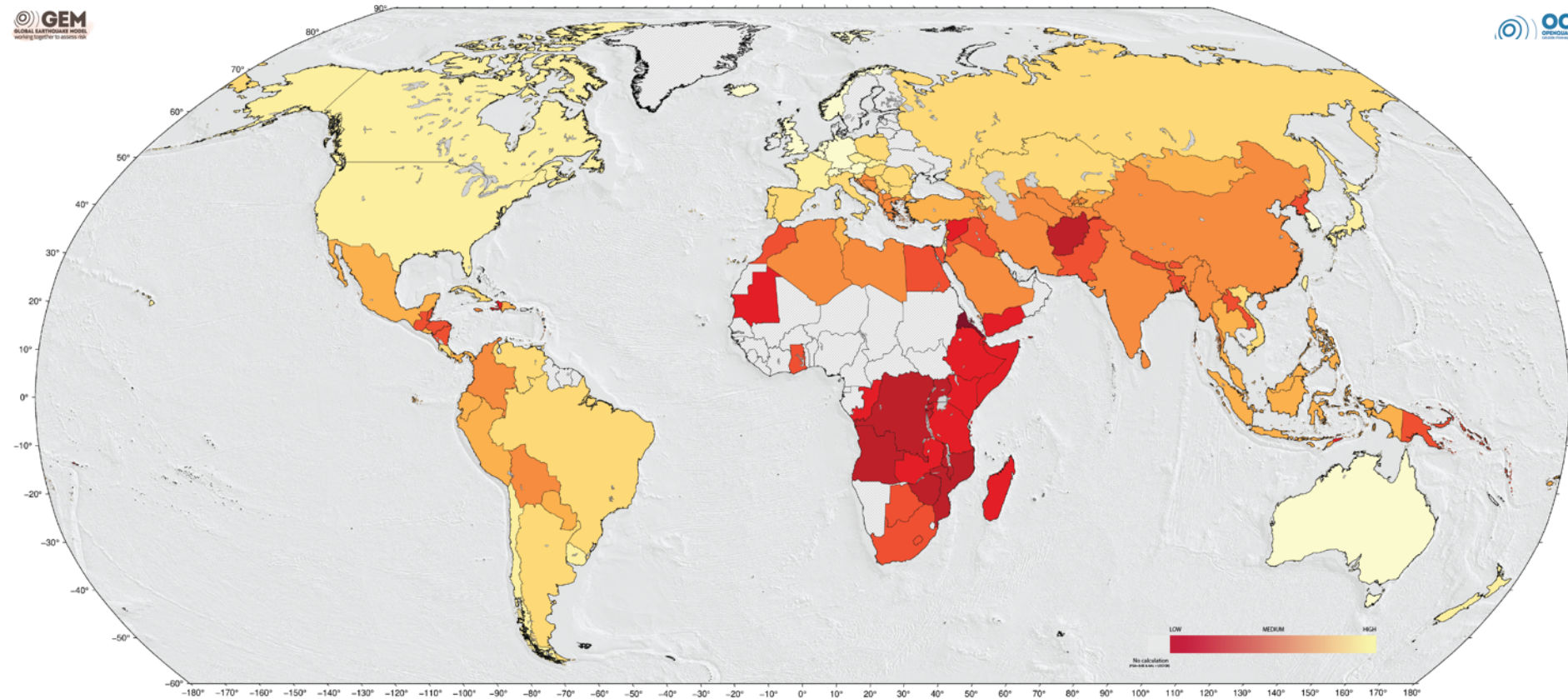
Research and development expenditures (+)

General government gross debt (-)

GINI Index (-)

% population with electricity access (+)

Age dependency ratio (-)

% population that is a foreign-born migrant (-)

% adult labor force participation (+)

% voter turnout at last parliamentary election (+)

% population in poverty (-)

Net migration rate (-)

Unemployment rate (-)

Road density (+)

Average household size (+)

Governance (Voice and Accountability Index) (+)

GDP per capita (+)

Illiteracy rate (-)

Remittance inflows in USD (+)

International tourism receipts as a percent of GDP (-)

Primary school completion rate (+)

% rural population

Bridging the Ivory Tower / Real-World Gap

Dr. Christopher G. Burton

christopher.burton@uconn.edu