# Leveraging and Improving GEM Tools to Assess and Communicate Integrated Risk and Resilience to Natural Hazards and Disasters

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## Improving the Integrated Risk Modelling Toolkit (IRMT): Approaches to Integrating Earthquake Risk and Social Vulnerability

### The Problem

Integrated earthquake risk has been described as the integration of physical earthquake risk assessments with metrics of social vulnerability (e.g., measures of characteristics within social systems that create the potential for loss or harm) [1]. There is a strong interest in the measurement of integrated risk, yet current methods and tools suffer from key limitations. Decision-makers, for instance, may have difficulties interpreting the meaning of the maps which could lead to uncertainty and misleading results that adversely affect policy decisions. A considerable degree of variation in modeling integrated risk also exists when considering visualization design, model construction, and aggregation procedures. Finally, social vulnerability models are sensitive to modeling decisions such as variable selection, weighting, and aggregation which leads to uncertainty in the results of any integrated risk assessment.

### Objectives

- Improve integrated risk modelling by defining optimal methodological approaches for integrating physical earthquake risk and social vulnerability, with an end goal of improved risk communication and decision-making.
- Better understand what model development decisions (e.g., variable selection, data standardization, weighting, and aggregation procedures) lead to the least amount of uncertainty in coupled risk and social vulnerability models.
- Improve GEM's Integrated Risk Modelling Toolkit by providing methodologically robust and stakeholder validated methods for integrated risk assessments.

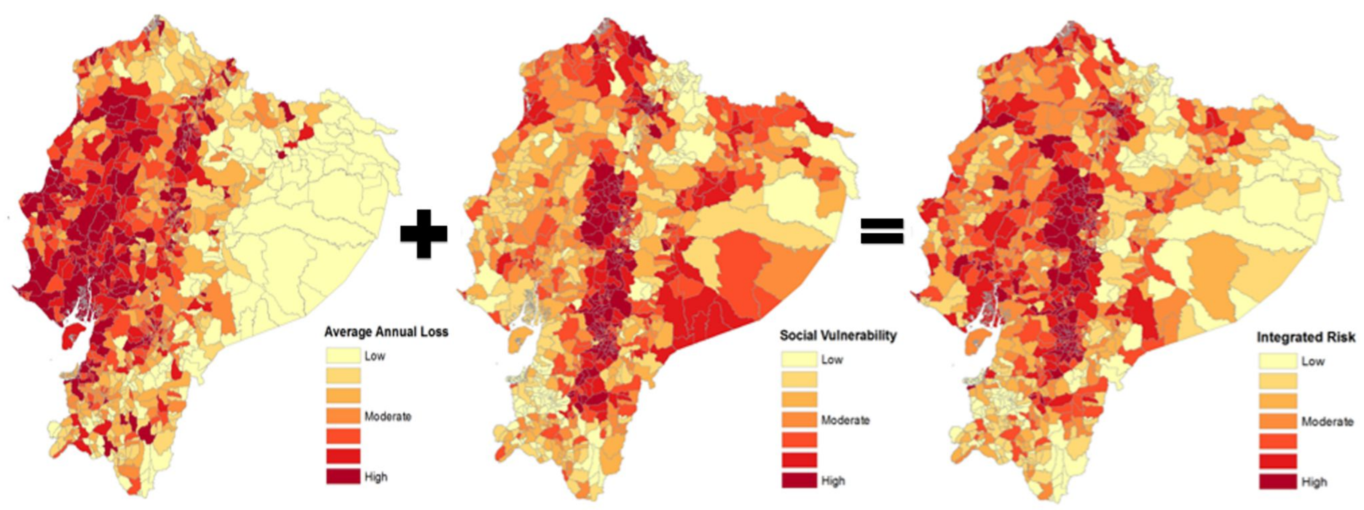


**Figure 1 -** Integrated risk example for Ecuador. **Source:** South America Risk Assessment (SARA) project [2]

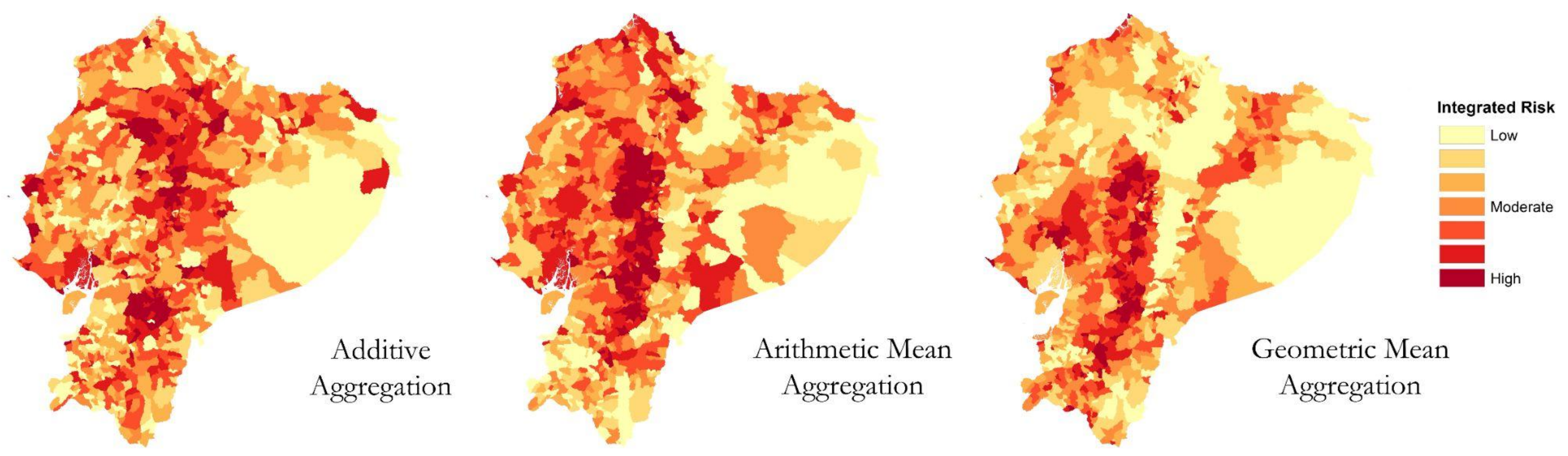


**Figure 2 -** Sample of different aggregation outcomes for integrating physical earthquake risk and social vulnerability. The mapped variability shows the effects of aggregation decisions on the resulting integrated risk model.

### Ongoing Workflow

Meta-analysis to identify earthquake specific variables and procedures (e.g., cartographic and mathematical) to integrate assessments of physical earthquake risk and social vulnerability

Monte carlo-based Sensitivity (SA) and Uncertainty Analysis (UA) to inform integrated risk and social vulnerability modelling procedures

Application of stakeholder needs and usability surveys to better understand how to best demonstrate and communicate integrated risk.

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View other methods for integrating risk.

**NOTE:** This project **is in a nascent stage of development**, and we hope to have the opportunity include the GEM family of affiliated scientists, industry leaders, and stakeholders in the application of stakeholder needs and product usability surveys.

### Benefits of the Work

- Development of combined risk and social vulnerability indices that are more robust.
- Improved understanding of model sensitivities and uncertainties.
- Improved communication of "integrated risk" to scientists and stakeholders for decision-making.

### References

[1] Burton C.G. and Silva V. (2016). Assessing Integrated Earthquake Risk in OpenQuake with an Application to Mainland Portugal. *Earthquake Spectra*, 32(3): 1383-1403.

[2] Valcárcel, J.A., Despotaki, V., Burton C.G., Yepes, C., Silva, V., Villacis, C., Terán, A., and Ordoñez, J. (2017). Integrated Assessment of Earthquake Risk in Quito, Ecuador using OpenQuake. *Proceedings of the 16th World Conference of Earthquake Engineering*, Santiago, Chile.

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## The GEM Resilience Performance Scorecard (RPS) in Action: Development of Metrics for Measuring the Resilience of Coastal Businesses along the Alabama and Mississippi Gulf Coast, USA

### The Problem

Communities that can increase their resilience to natural hazards and disasters are in a better position to absorb damage impacts and to recover from them when adverse impacts occur. There is a strong interest in the measurement of disaster resilience as a result, yet the measurement of resilience is difficult. Current resilience metrics suffer from key limitations that include the lack of validation and the overutilization of "broadly-brushed" indicator-based approaches that ignore both hazard and community contexts.

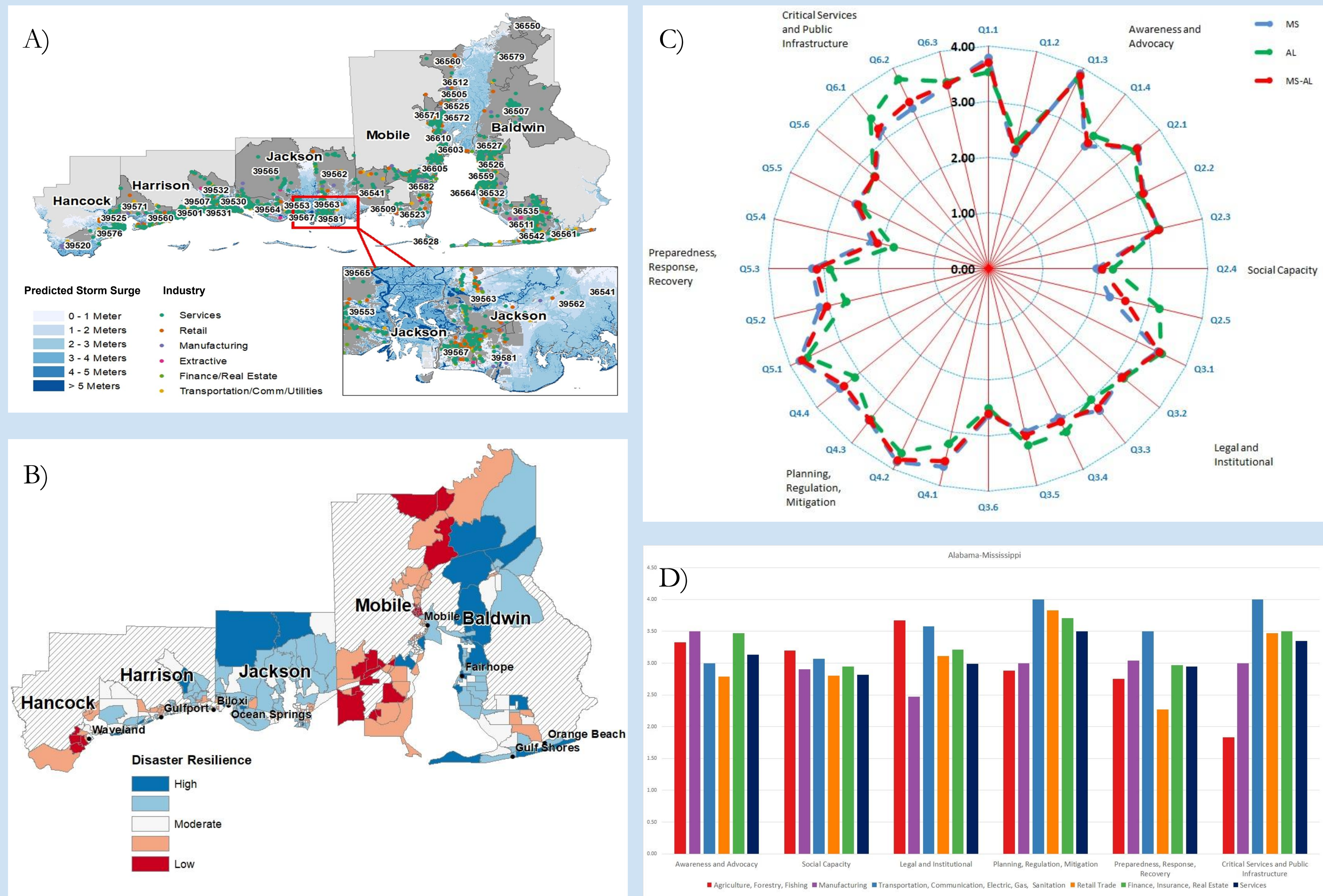


**Figure 1 -** A) Exposure of industry types to predicted storm surge under a 0.25 meter SLR scenario [1], B) validated disaster resilience index using recovery from Hurricane Katrina [2], C) results from Resilience Performance Scorecard (RPS) [3] by state where each spoke corresponds to a question and outer portions of the wheel represent higher scores, D) RPS results for the study area by industry type.

### Objectives

- Assess "who" and "what" is at risk to future storm surge hazards exacerbated by Sea-level Rise (SLR) along the Mississippi and Alabama Gulf Coast.
- Account for hazard context by employing a community resilience index that was validated using the recovery of Mississippi and Alabama coastal communities from Hurricane Katrina (2005-2017).
- Account for community context by evaluating the resilience of small businesses using a version of GEM's Resilience Performance Scorecard (RPS) that was modified to account for important aspects of organizational resilience and the interactions between businesses and the communities that sustain them.

### Methods

- **Tier 1:** Spatial analysis of exposed businesses and communities located in predicted SLR induced tropical cyclone storm surge zones.
- **Tier 2:** Capture hazard and community context using a community resilience index that was validated using the recovery of the Mississippi and Alabama Gulf Coast following Hurricane Katrina [2].
- **Tier 3:** Capture livelihood context through the application of GEM's Resilience Performance Scorecard (RPS) [3] that was modified to account for important aspects of organizational resilience and sent to approximately 4500 coastal businesses.

### Findings

- Service industry businesses and retail establishments are most susceptible to SLR-related hazards and disasters.
- Areas with the lowest resilience are located along the Mississippi coast in Hancock and Harrison counties.
- Coastal businesses in both states identified similar gaps and strengths in their resilience using the modified RPS. Relevant gaps include the lack of post-disaster recovery planning, the lack of a means to ameliorate supply chain disruptions, and the lack of pre-disaster infrastructure mitigation.
- RPS responses that were evaluated by industry type are not similar. The lowest scores were found within the service and retail sectors.

### References

[1] National Centers for Coastal Ocean Science (2020), The Effects of Sea Level Rise Program (ESLR), National Oceanic and Atmospheric Administration (https://coastalscience.noaa.gov/).

[2] Burton C.G. (2015). A Validation of Metrics for Community Resilience to Natural Hazards and Disasters using the Recovery from Hurricane Katrina as a Case Study. *Annals of the Association of American Geographers*, 150(1): 67–86.

[3] Khazai, B., Anhorn, H., and Burton C.G. (2018). Resilience Performance Scorecard: Measuring Urban Disaster Resilience at Multiple Levels of Geography, *International Journal of Disaster Risk Reduction*, 31: 604-616.

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View summary of project results.

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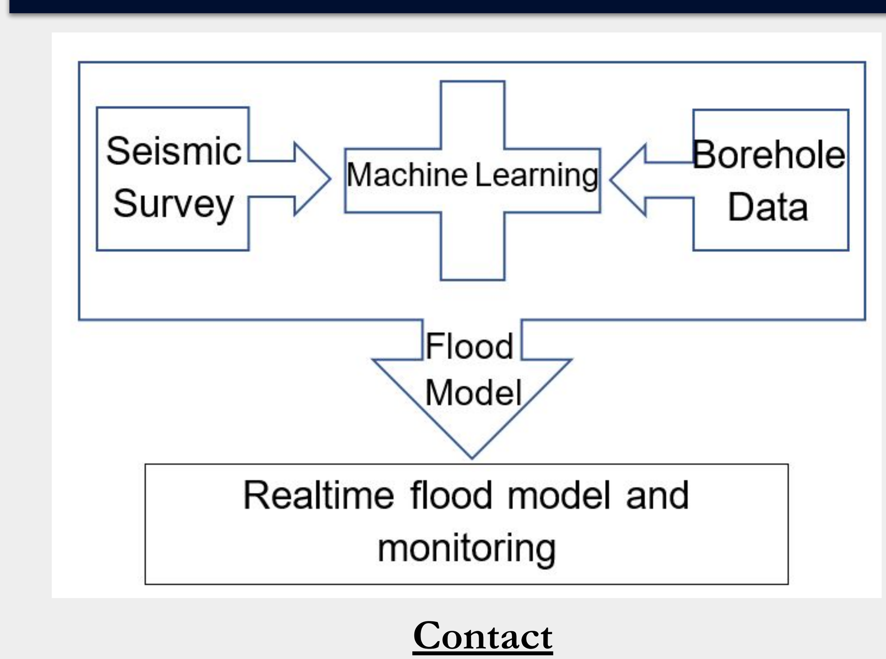
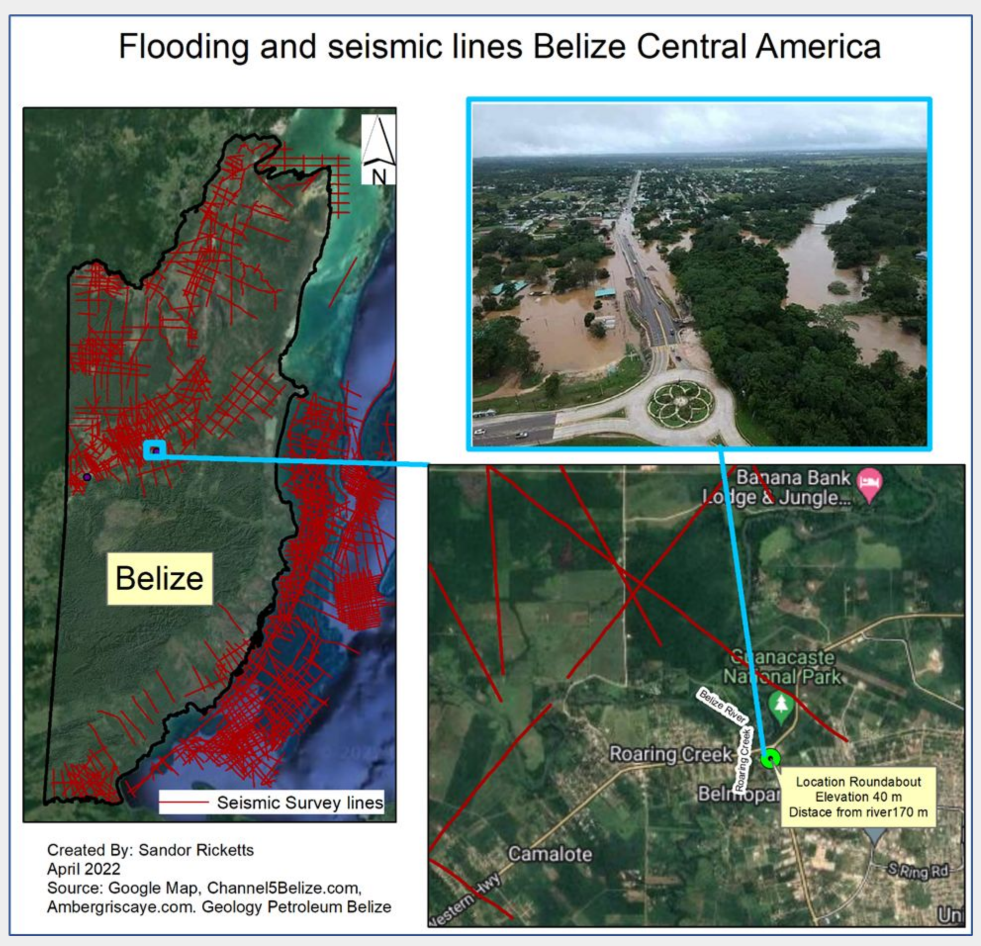
## Another Notable Project: Flood Model Enhancement Through Machine Learning via Seismic and Borehole Data Integration

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