Flood resilience disparities: The intersection between economic and health risks in Can Tho, Vietnam

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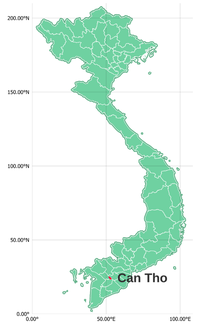
Background – Can Tho, Vietnam



- Can Tho is located in the highly flood-prone southern region of the Mekong Delta, along the Hau River
- Changing climate and population growth influence the severity of flood events
- Floods cause consequences to economic sectors and human-health and wellbeing.
- Enteric diseases due to flooding was found to cause a high burden to the medical sector[1]

Vietnam, Can Tho city[2]

Objectives

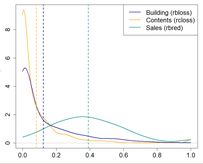
- Elucidate the disparities in flood consequences with a focus on **residential, commercial and health impacts** in Can Tho city
  - Develop uni- and multi-variable flood loss models from empirical data
  - Focus on losses to residential buildings (bloss) and shophouses, related to content (closs) and sales reduction (bred)
  - Estimate the expected number of enteric disease cases in vulnerable populations (age ≤ 5 or age ≥ 65) resulting from exposure to microbial contamination present in floodwaters, using Quantitative Microbial Risk Assessment (QMRA)

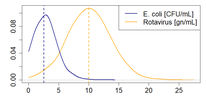
Materials

- **Hazard simulations:** Probabilistic (2, 5, 10, 20, 50 and 100 year return period) flood inundation scenarios for compound fluvial-pluvial flooding[3] (*ongoing*)
- **Exposure:** Location, building use and structural value of residential and commercial buildings, along with the topography of the surroundings (slope)
- **Vulnerability:** Surveys for residential and shop households (n = 479; n = 337, respectively)[4]. Laboratory analysis of flood and sewer water samples (n = 30)[1]

Modelling approach

1. Bayesian regressions for the **prediction of flood losses and concentration of microbial contamination**



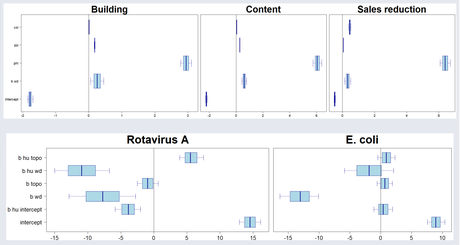


(L) Density of relative losses to buildings, contents, and sales – zero one beta inflated regressions
(R) Density of concentrations pathogens (log scale) – hurdle lognormal regressions

2. Metrics and performance

	MAE	RMSE	MBE	MEAN CRPS
bloss	0.135	0.190	-0.022	0.081
closs	0.097	0.153	-0.009	0.062
bred	0.166	0.210	-0.001	0.118
rota	3.47E7	5.43E7	-3.47E7	4.19E5
ecoli	3.78E4	6.36E4	-3.72E4	7.36E2

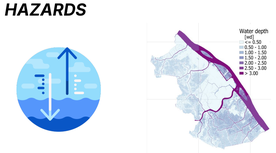
bloss – building loss; closs – content loss; bred business reduction; rota – rotavirus; ecoli – E. coli
b = Bayesian regression slope coefficients; topo = topographic slope of the terrain (exposure layer)



- Negative MBE of small magnitude suggests a slight overestimation
- Low values of Mean CRPS indicate better predictive capacity of the models

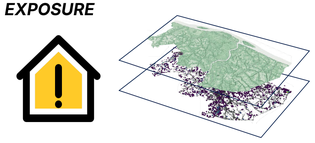
Application

HAZARDS



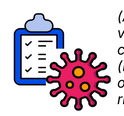
Water depth of six return periods with present and future scenarios

EXPOSURE



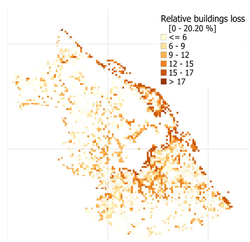
Slope, structural value of households

VULNERABILITY



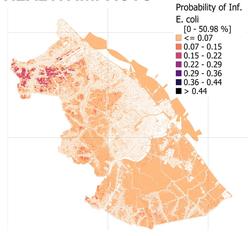
(A) Survey data: building value, inundation depth, sales, contents, exposure time
(B) Sampling for concentration of pathogen and distance to river.

(A) ECONOMIC IMPACTS



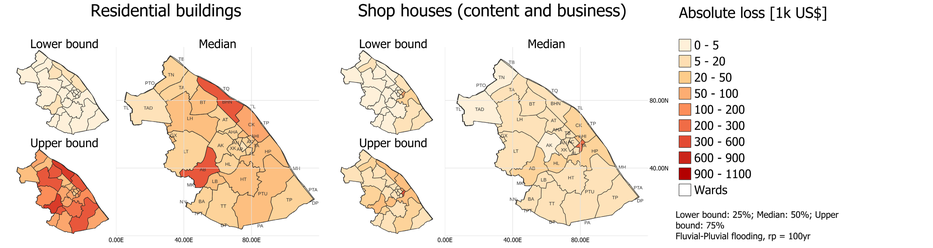
Relative losses for buildings, contents and sales to absolute losses

(B) HEALTH IMPACTS



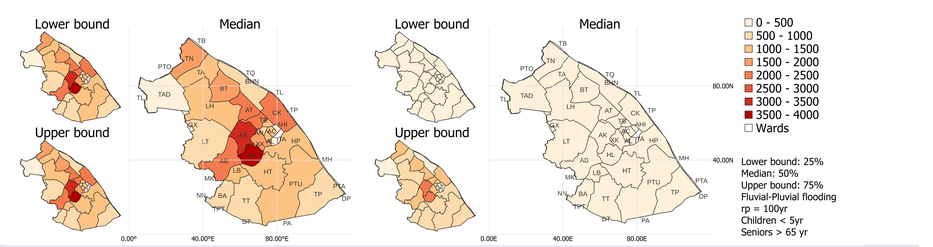
QMRA based on concentration predictions of the pathogens, intake dose, time of exposure. and dose-response assessments

Absolute losses



- **Residential buildings** present higher **absolute losses** in An Binh (AB) Bui Huu Nghia (BHN)
- **Shop houses** losses contemplate **content loss and business reduction** from reduced sales
  - The highest loss is found in Tra An (TA) ward
- The spatial patterns of commercial losses are similar to residential losses, although significantly lower in magnitude → the higher the building value, the higher the losses

Illness due to exposure to floodwaters – Expected cases of enteric diseases in vulnerable populations



- E. *coli* has a lower **probability of illness and consequently low numbers of expected cases** in comparison to that of Rotavirus A
- Rotavirus A has a higher illness probability per dose (minimal exposure may lead to illness)
  - E. *coli* requires higher **ingestion doses** to reach higher probabilities of infection and illness
  - The highest probabilities are seen in districts closer to the River Hau and north of Can Tho
- Number of **expected cases** from the probability of illness and population (by age groups)
  - Higher cases for Rotavirus A (3,584, Q50) vs E. *coli* (474, Q50)
  - Concentration of cases around An Khanh (AK) and Hung Loi (HL) → densely populated areas

Conclusions and outlook

- Improve prediction models with the inclusion of additional predictors (*ongoing*)
  - E.g., Dose-response for different age groups, time of exposure by activity, and sewer system capacity
- Spatial information on economic and health risks can be used for response and adaptation planning in the city of Can Tho
  - Additional drivers can help estimating the risks more accurately (e.g., precautionary measures, accessibility to healthcare facilities)

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3. Apel et al. 2015. Combined fluvial and pluvial urban flood hazard analysis: concept development and application to Can Tho city, Mekong Delta, Vietnam
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