



# Globally consistent, open-source river flood impact model using open data

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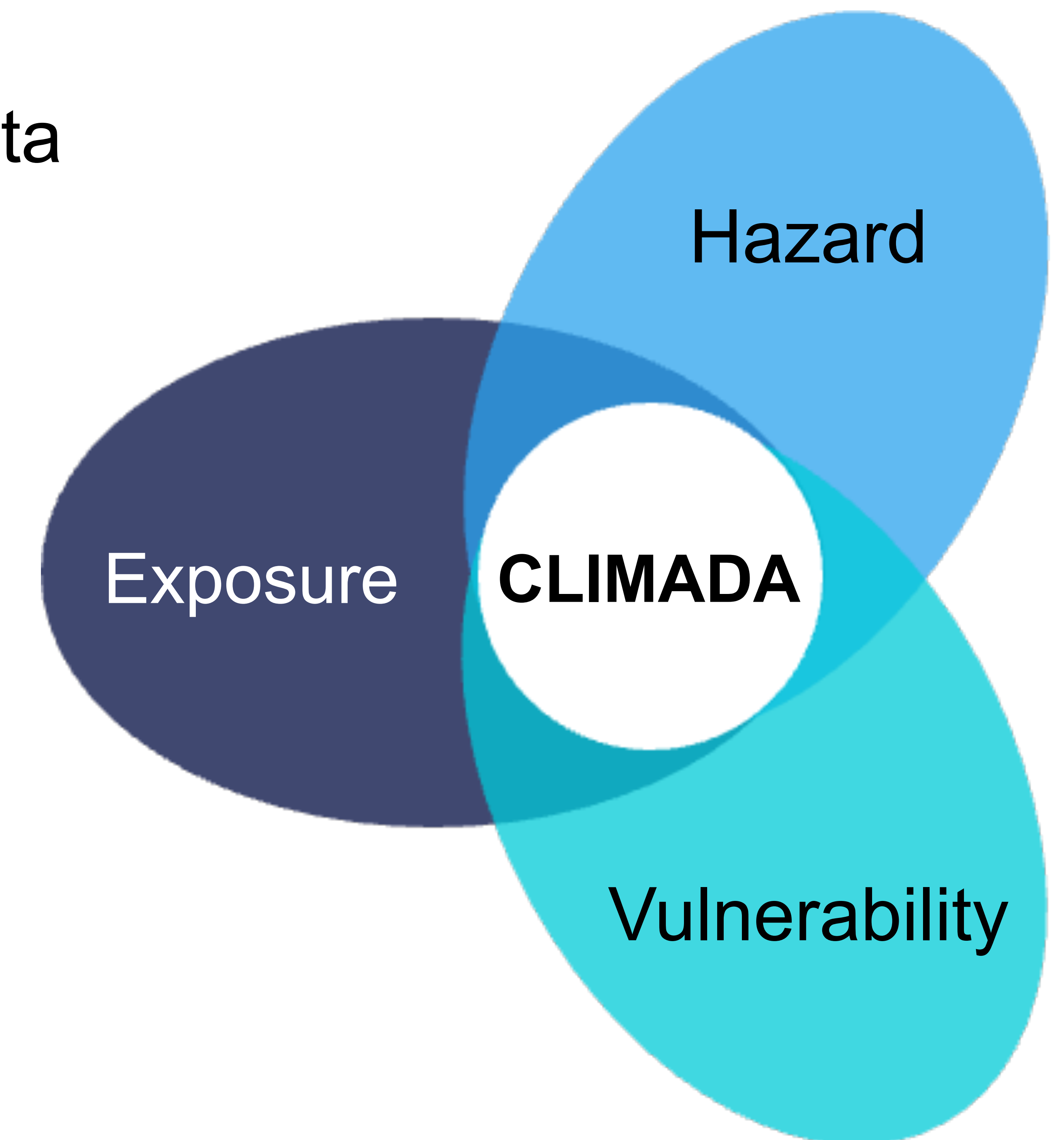
# Project Overview

## Goals

- Develop open-source **river flood inundation** model based on open data
- Forecast river flood **impacts** on short- to medium-range time scale
- Support **anticipatory action** and disaster relief efforts

## Data Sources

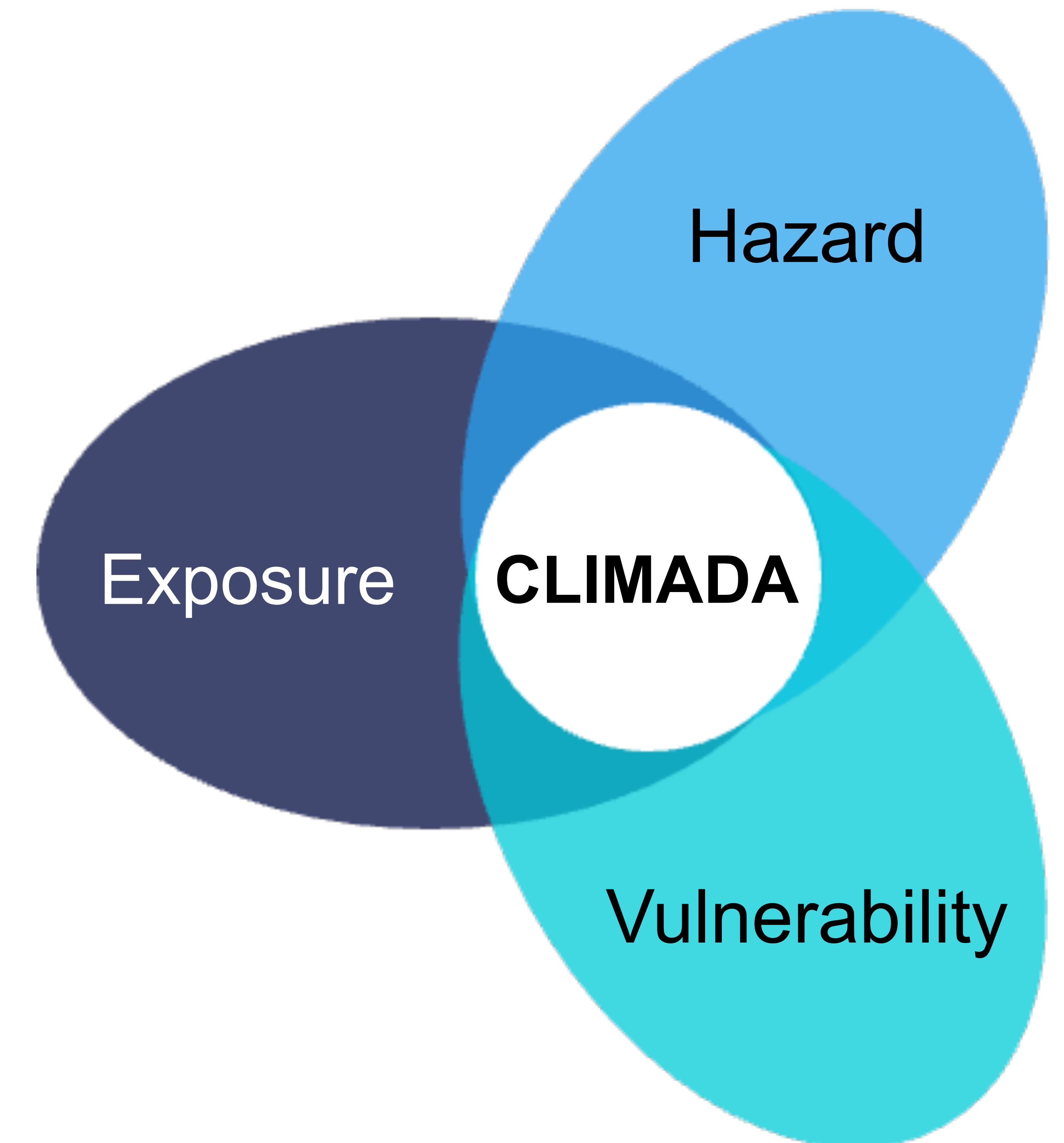
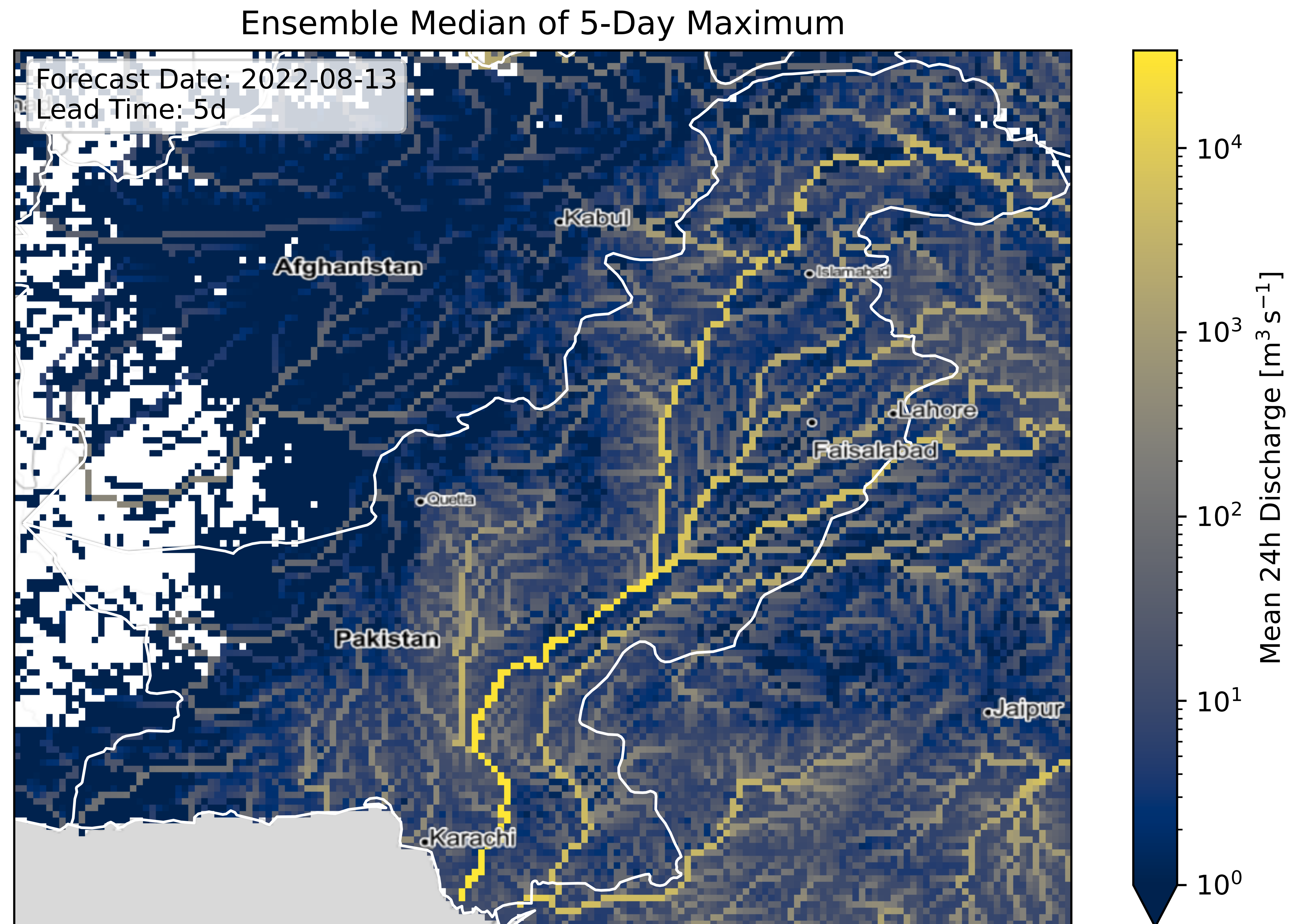
- River discharge (GloFAS, Copernicus Climate Data Store)
  - Daily ensemble forecasts
  - Daily reanalysis data from 1980 onwards
- Flood hazard maps (EC JRC Data Catalogue)
- Gridded Population of the World (GPW), NASA Black Marble
- FLOPROS flood protection database



# Flood Impact: Potential Displacement of Population

## Pakistan 2022 Flood Showcase

### GloFAS River Discharge



# Flood Impact: Potential Displacement of Population

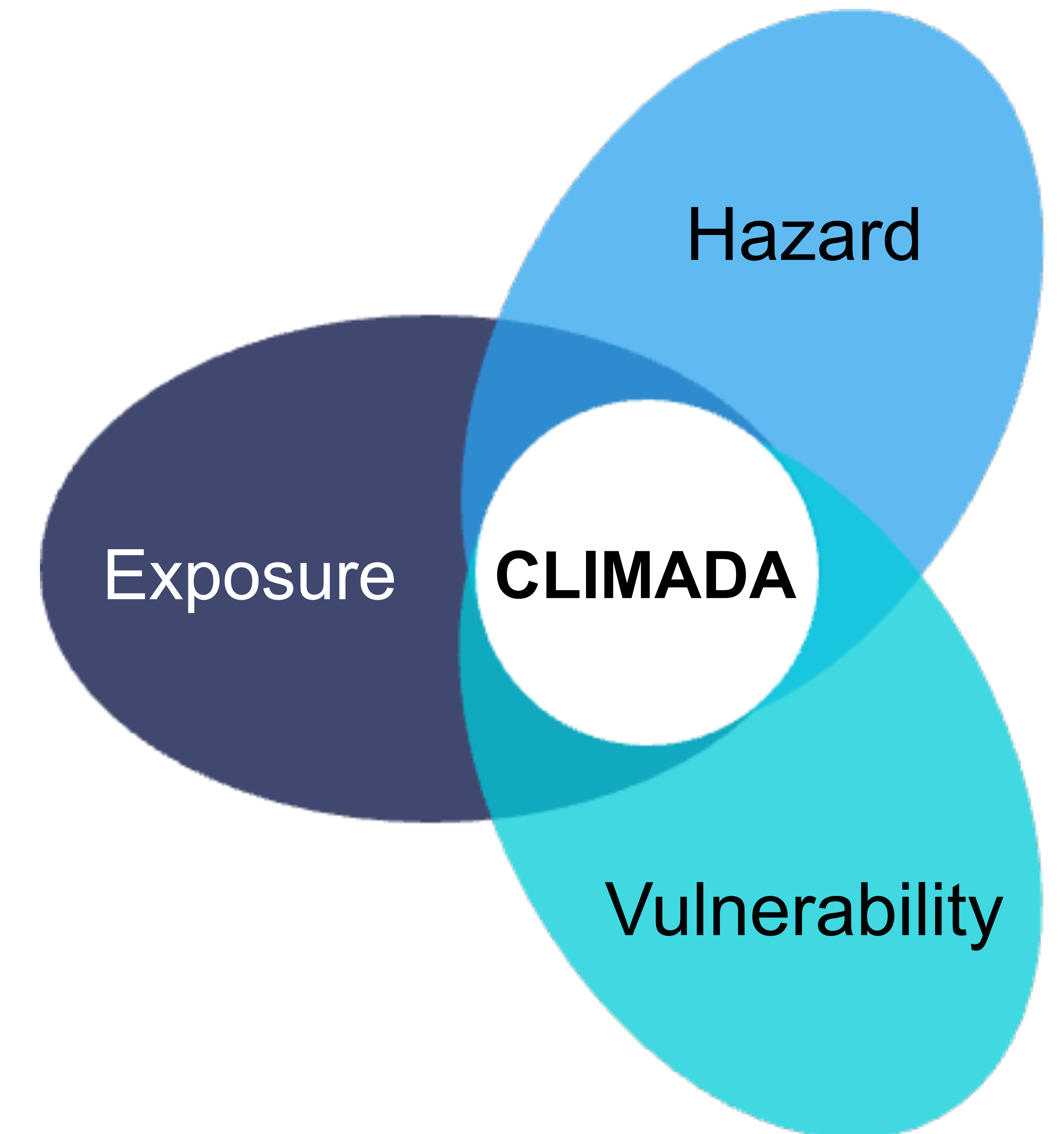
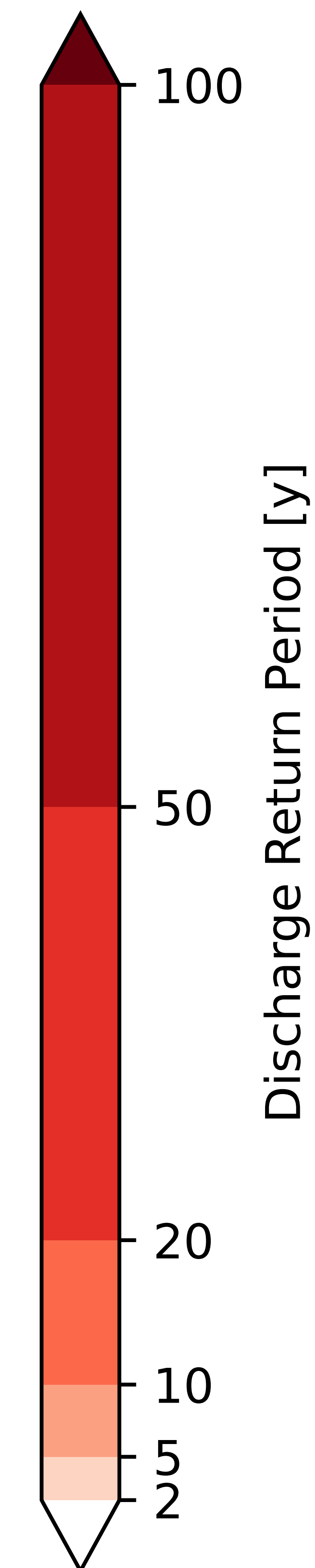
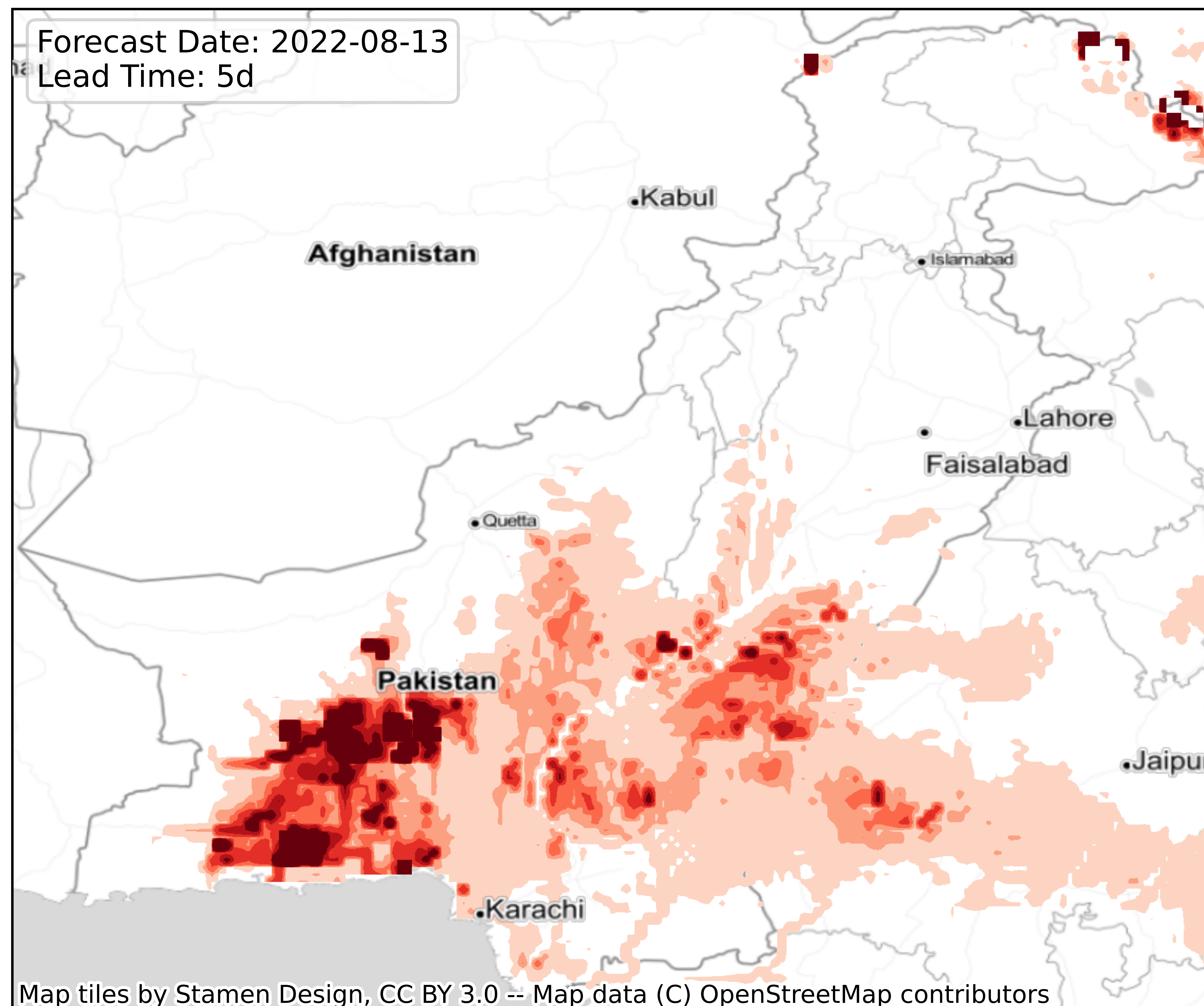
## Pakistan 2022 Flood Showcase

GloFAS River Discharge



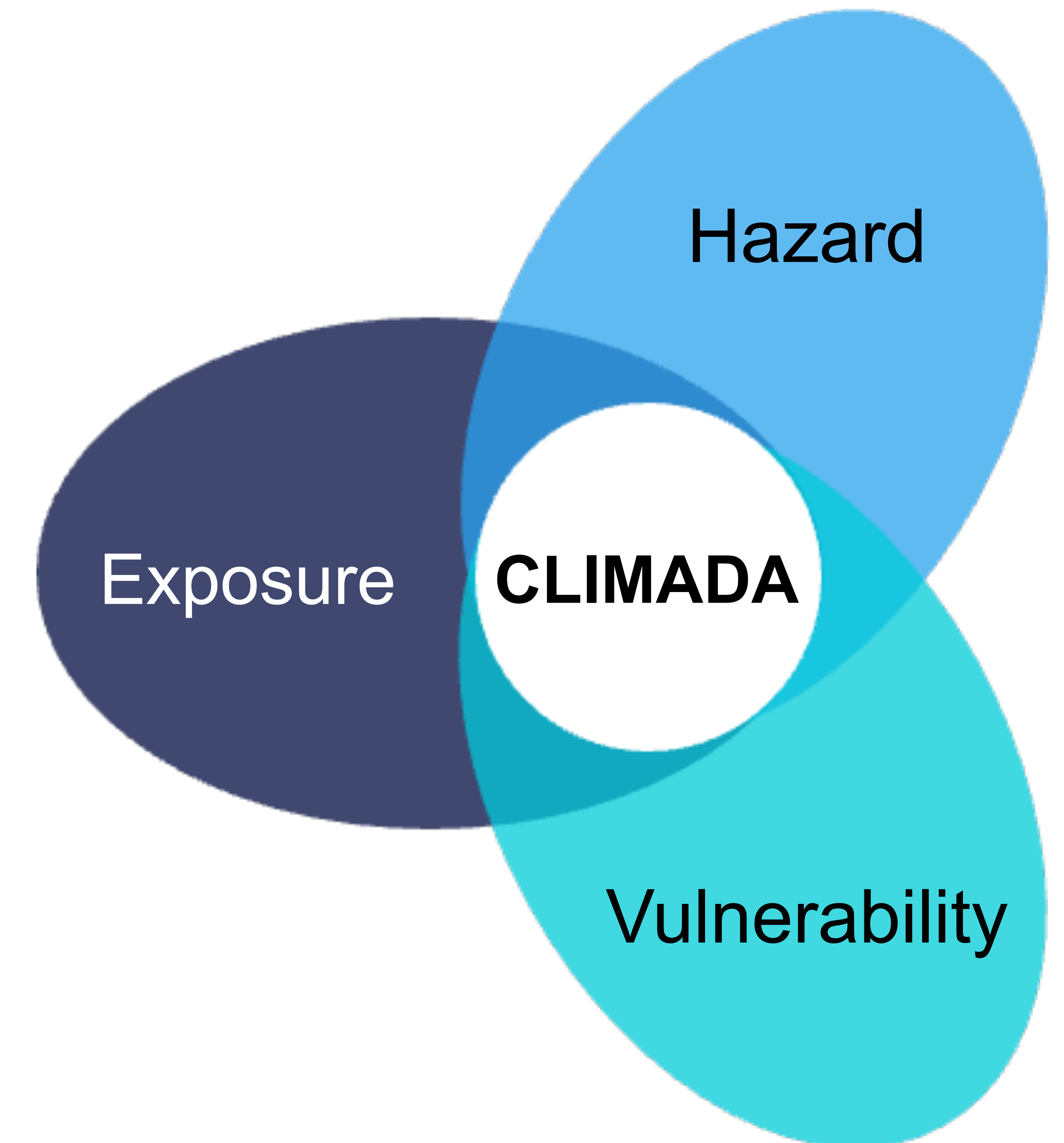
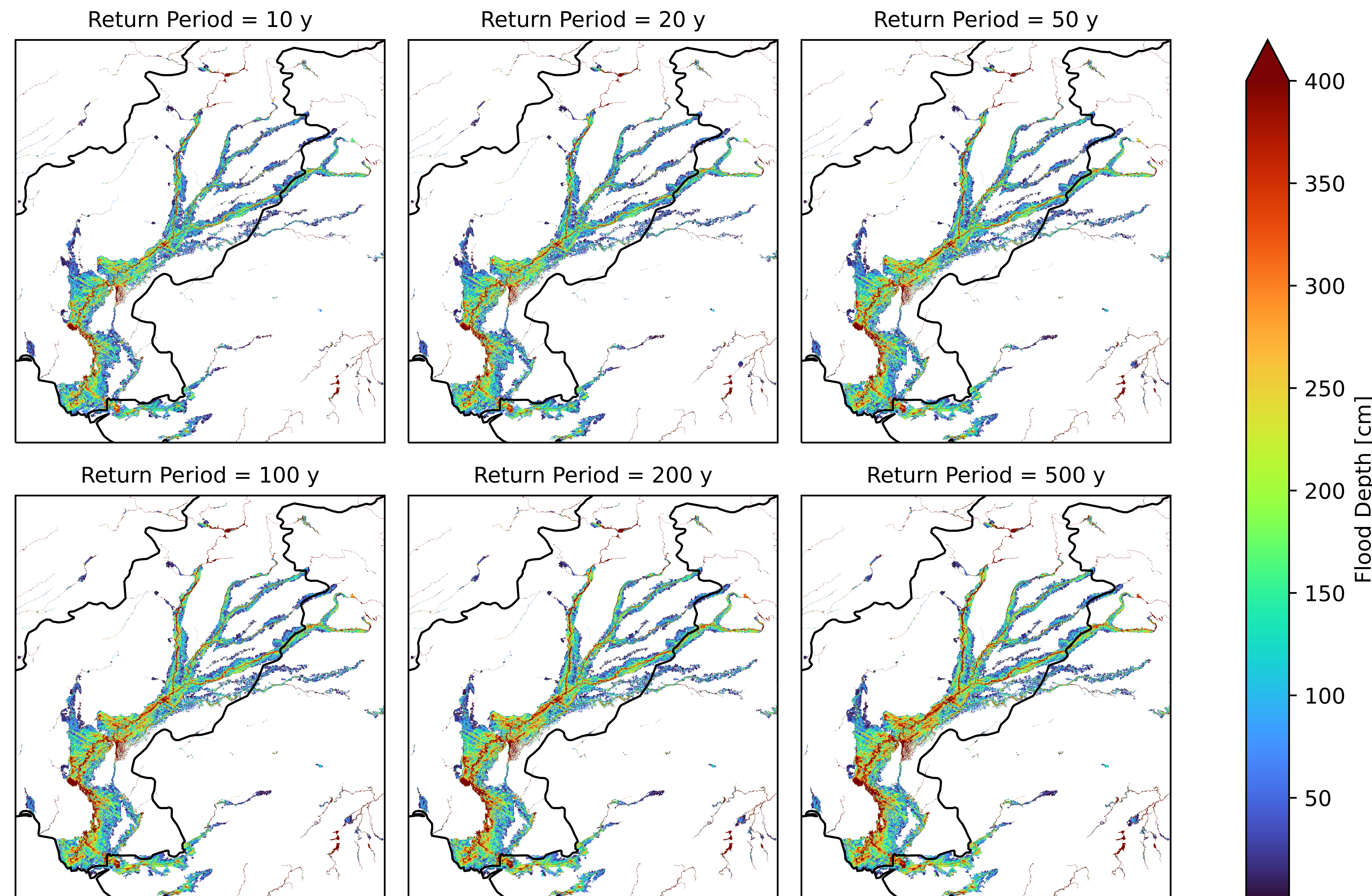
Return Period

Ensemble Median of 5-Day Maximum



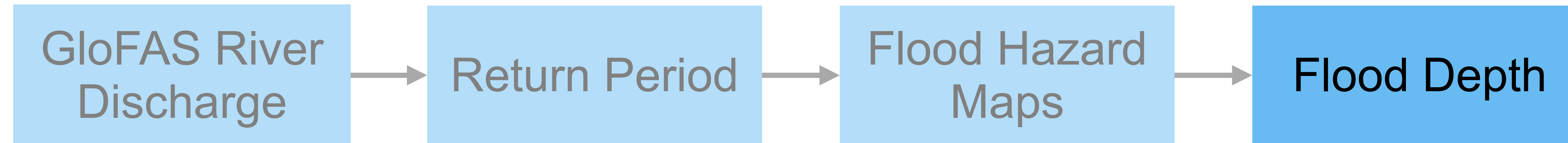
# Flood Impact: Potential Displacement of Population

## Pakistan 2022 Flood Showcase

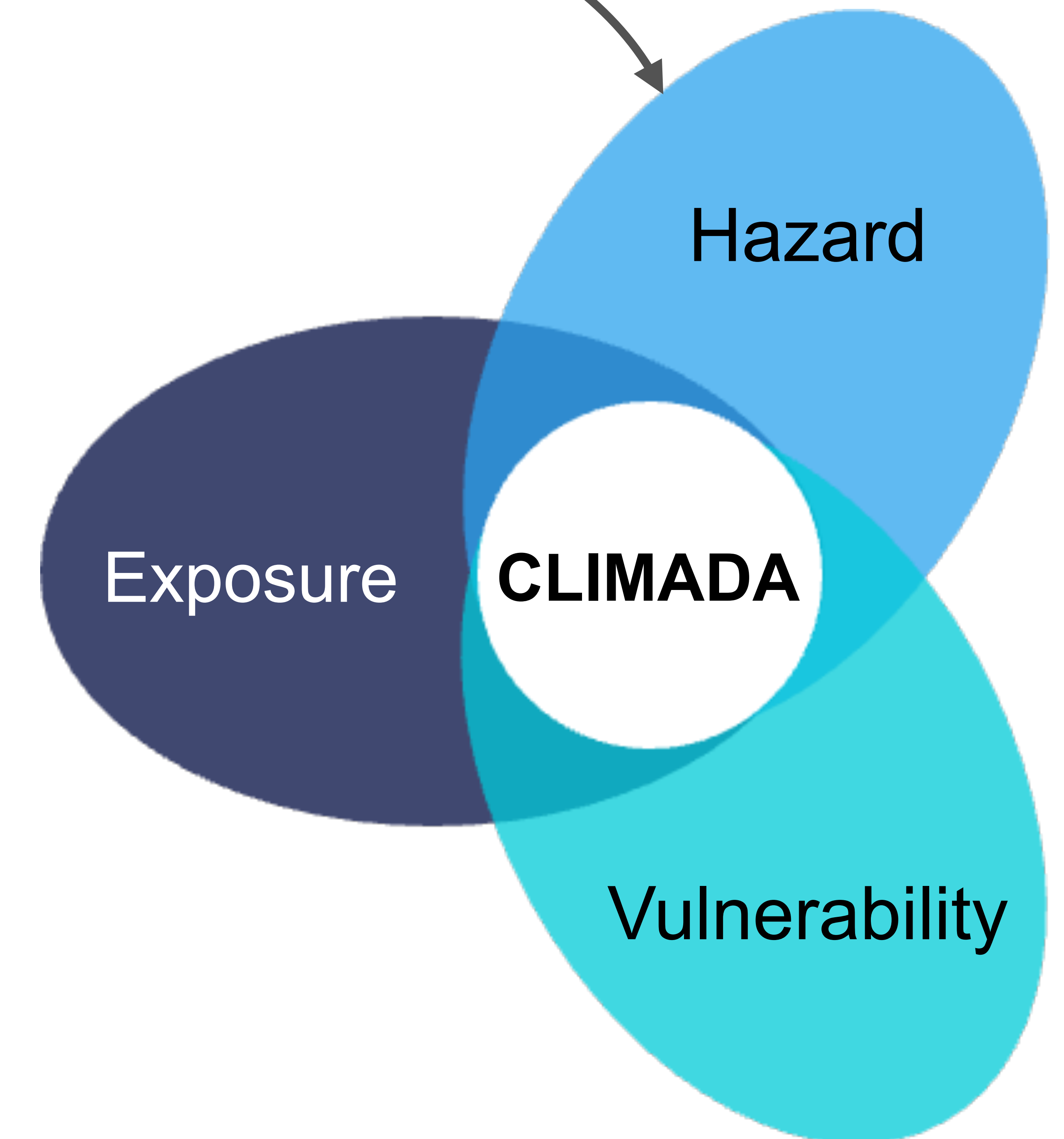
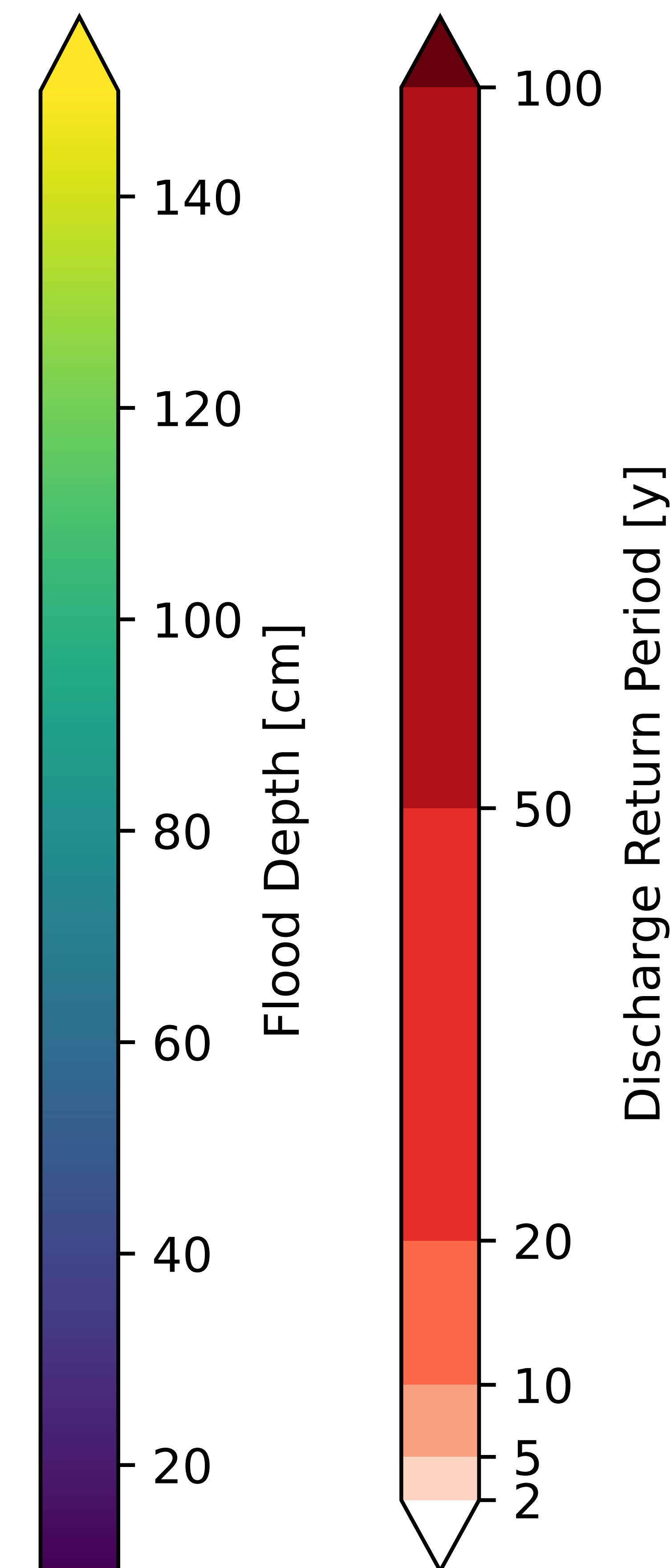
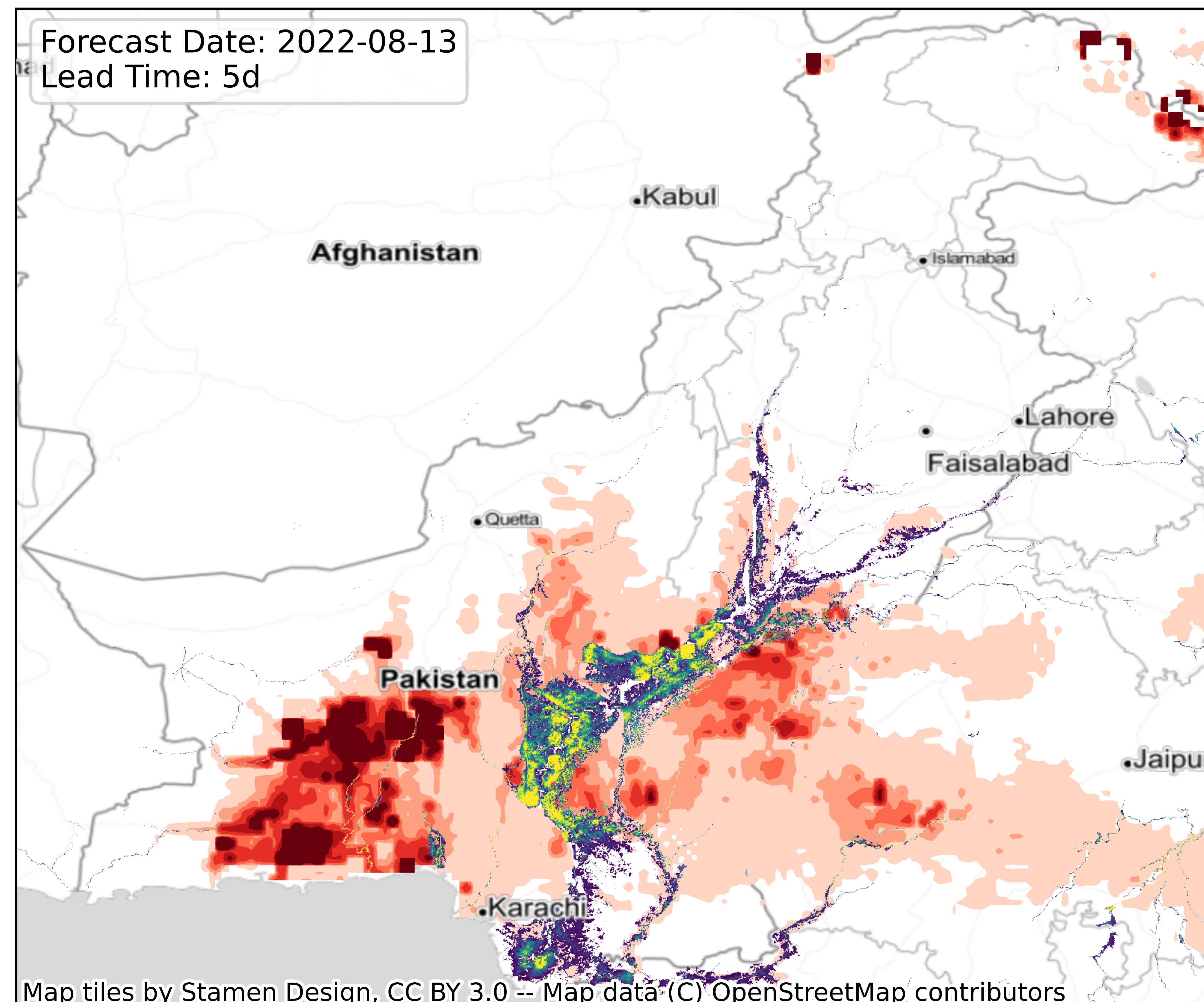


# Flood Impact: Potential Displacement of Population

## Pakistan 2022 Flood Showcase

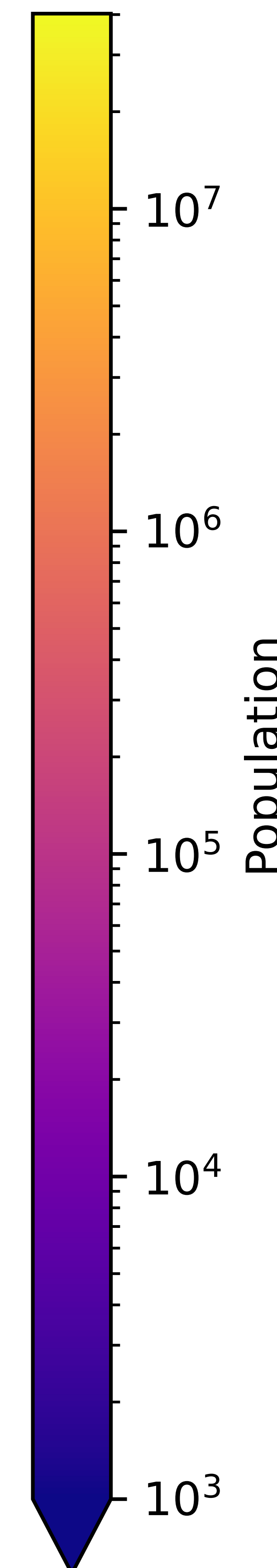
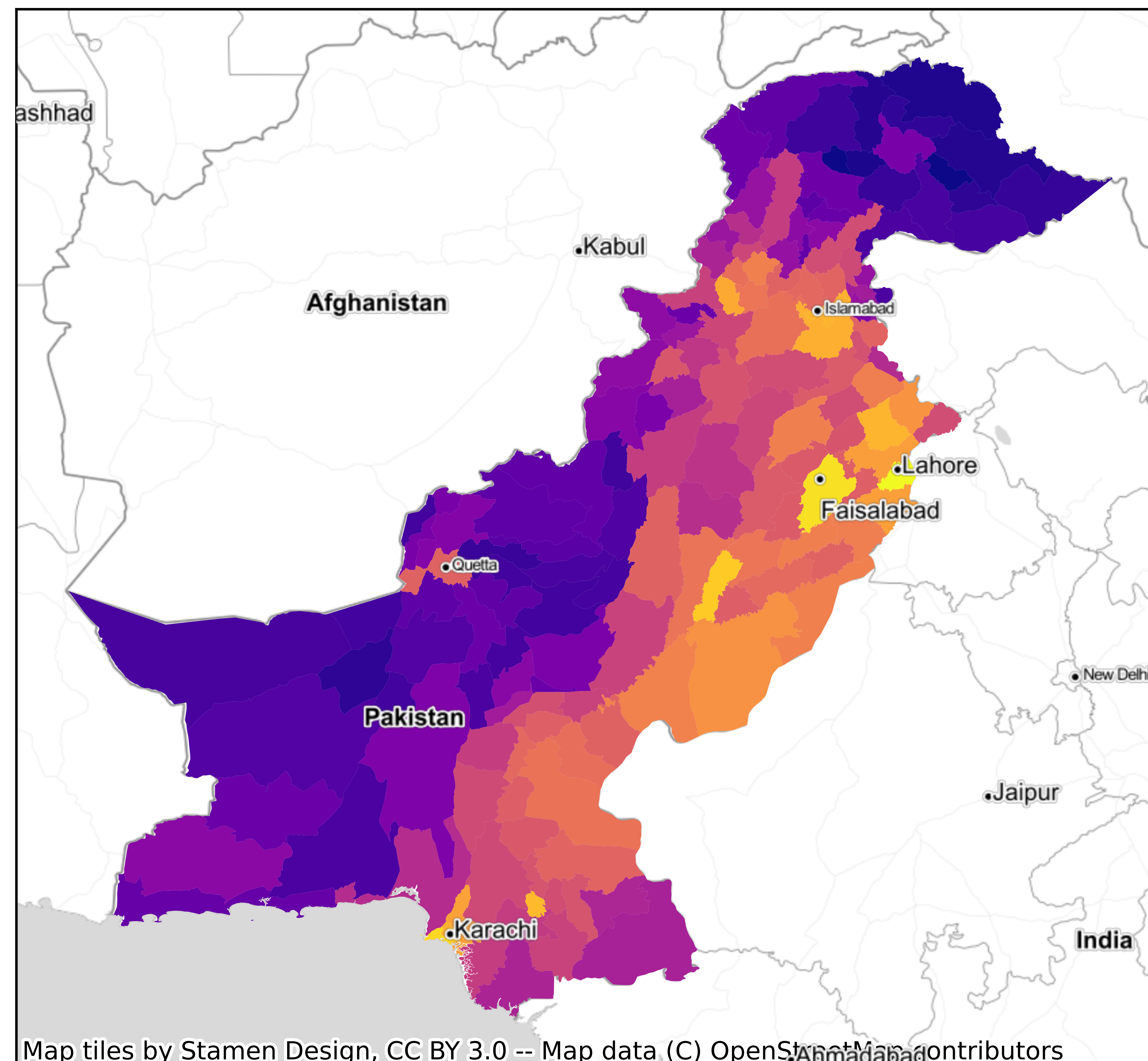
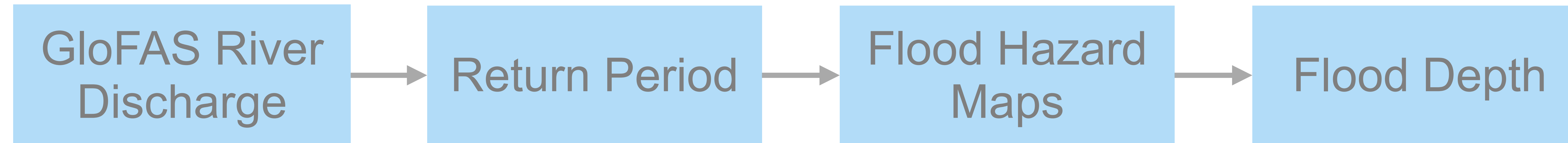


Ensemble Median of 5-Day Maximum



# Flood Impact: Potential Displacement of Population

## Pakistan 2022 Flood Showcase



GPW v4,  
Black Marble

Exposure

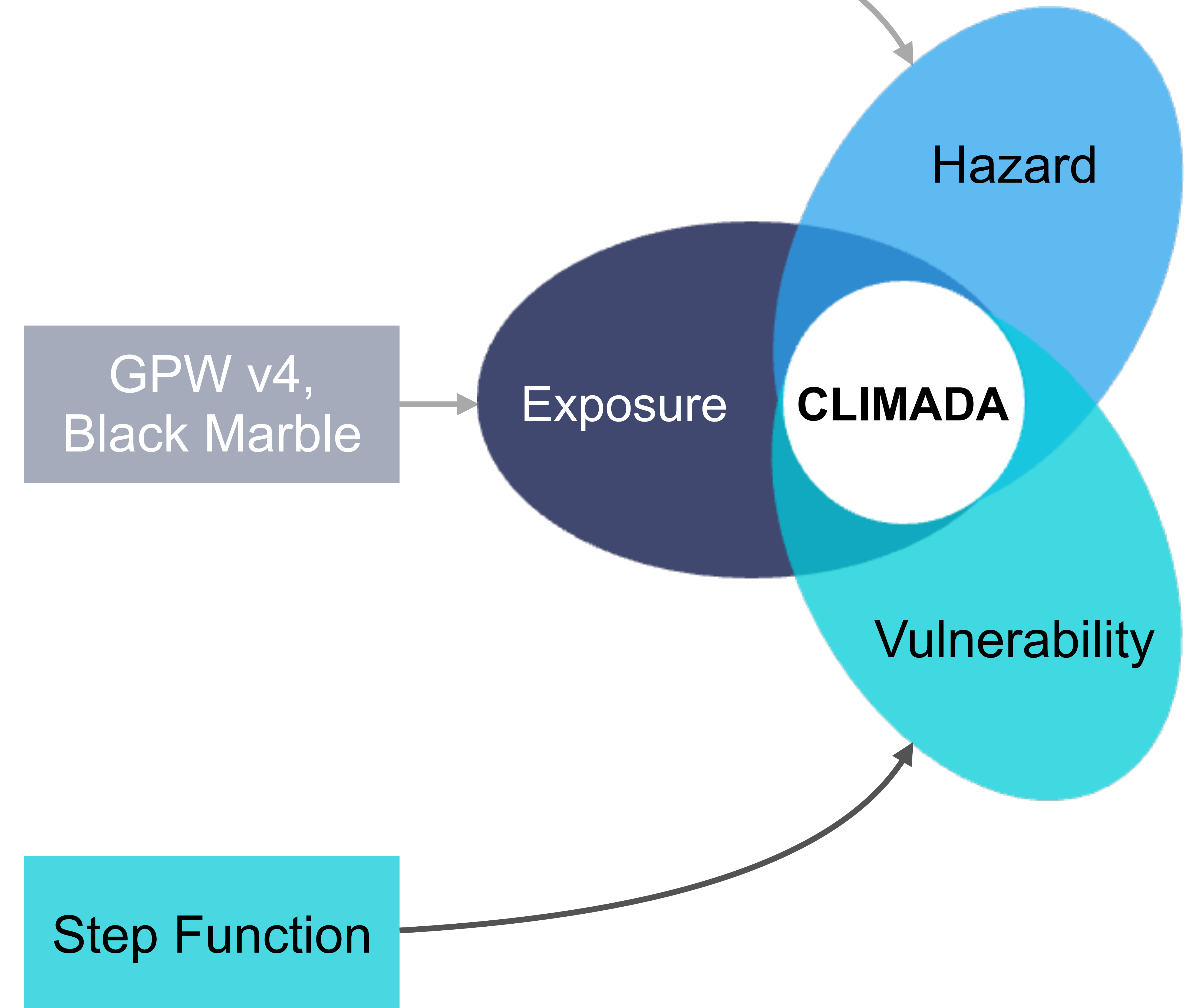
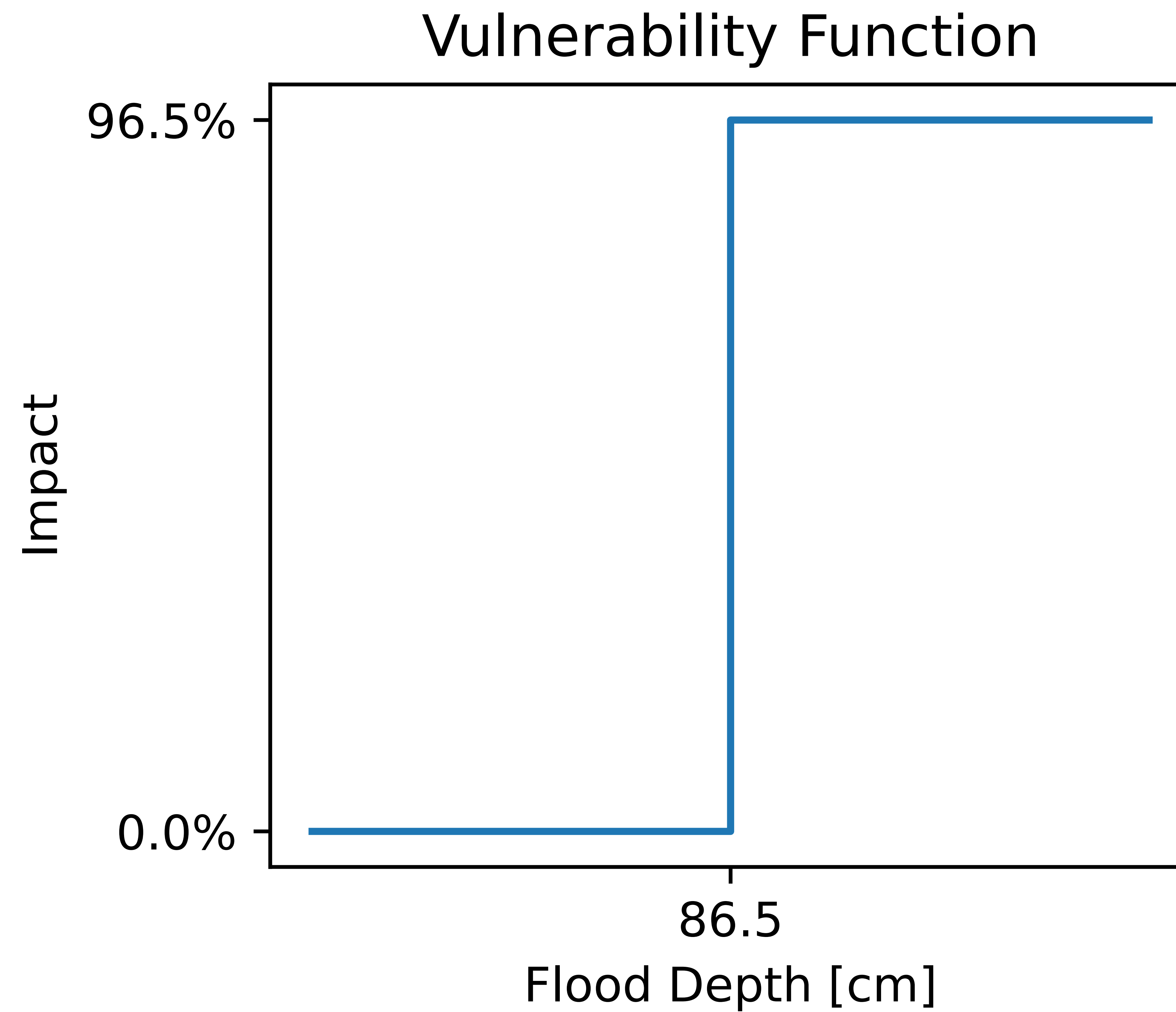
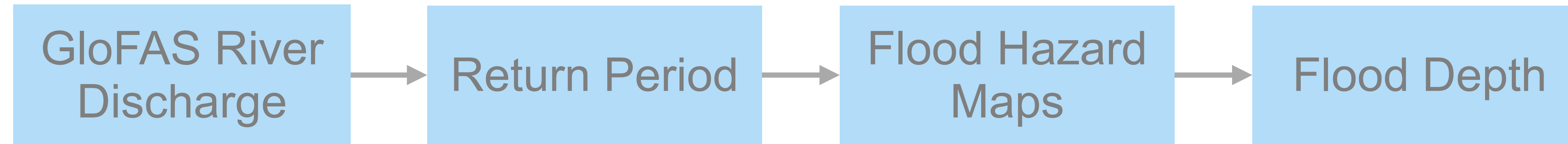
**CLIMADA**

Vulnerability

Hazard

# Flood Impact: Potential Displacement of Population

## Pakistan 2022 Flood Showcase

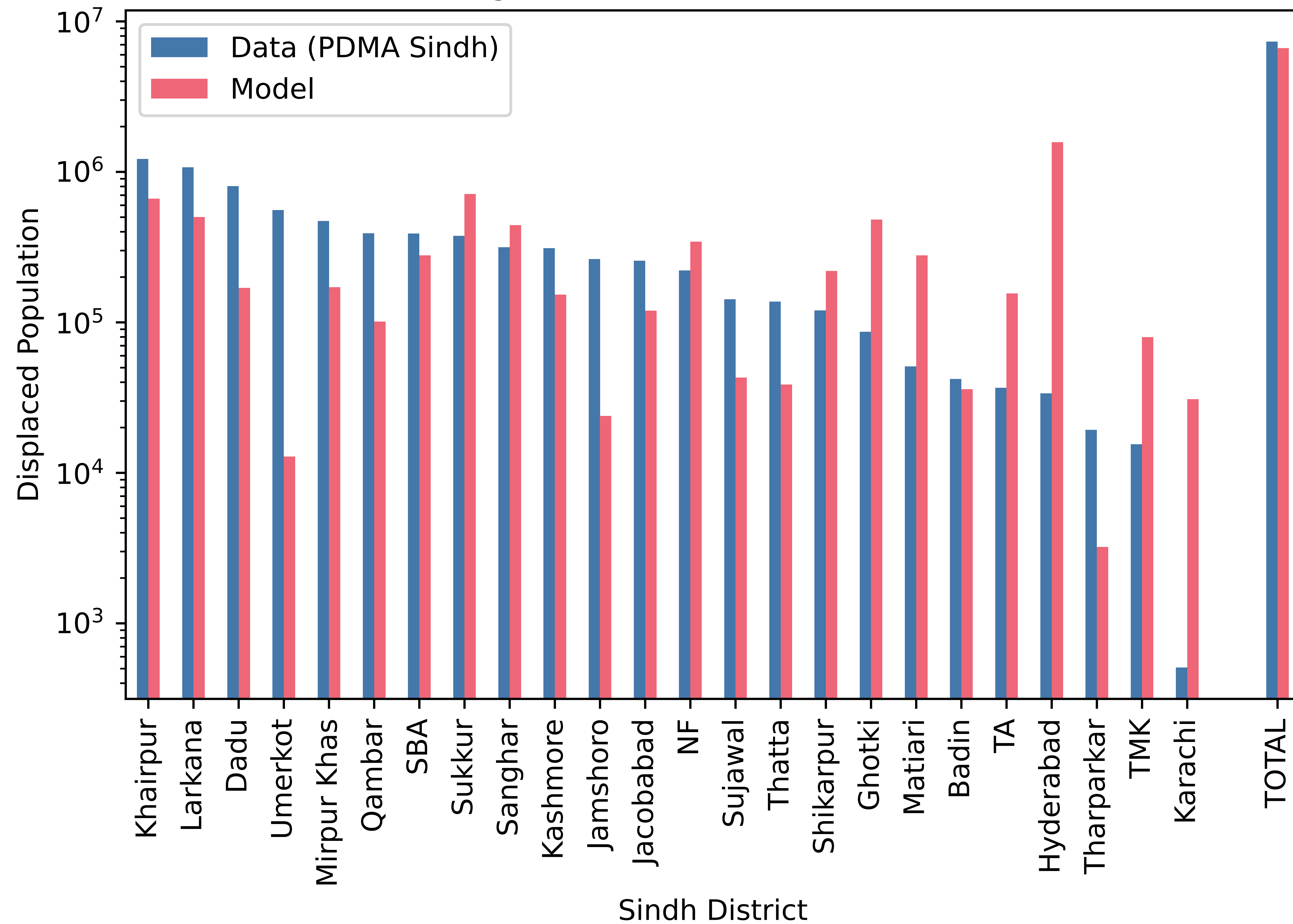




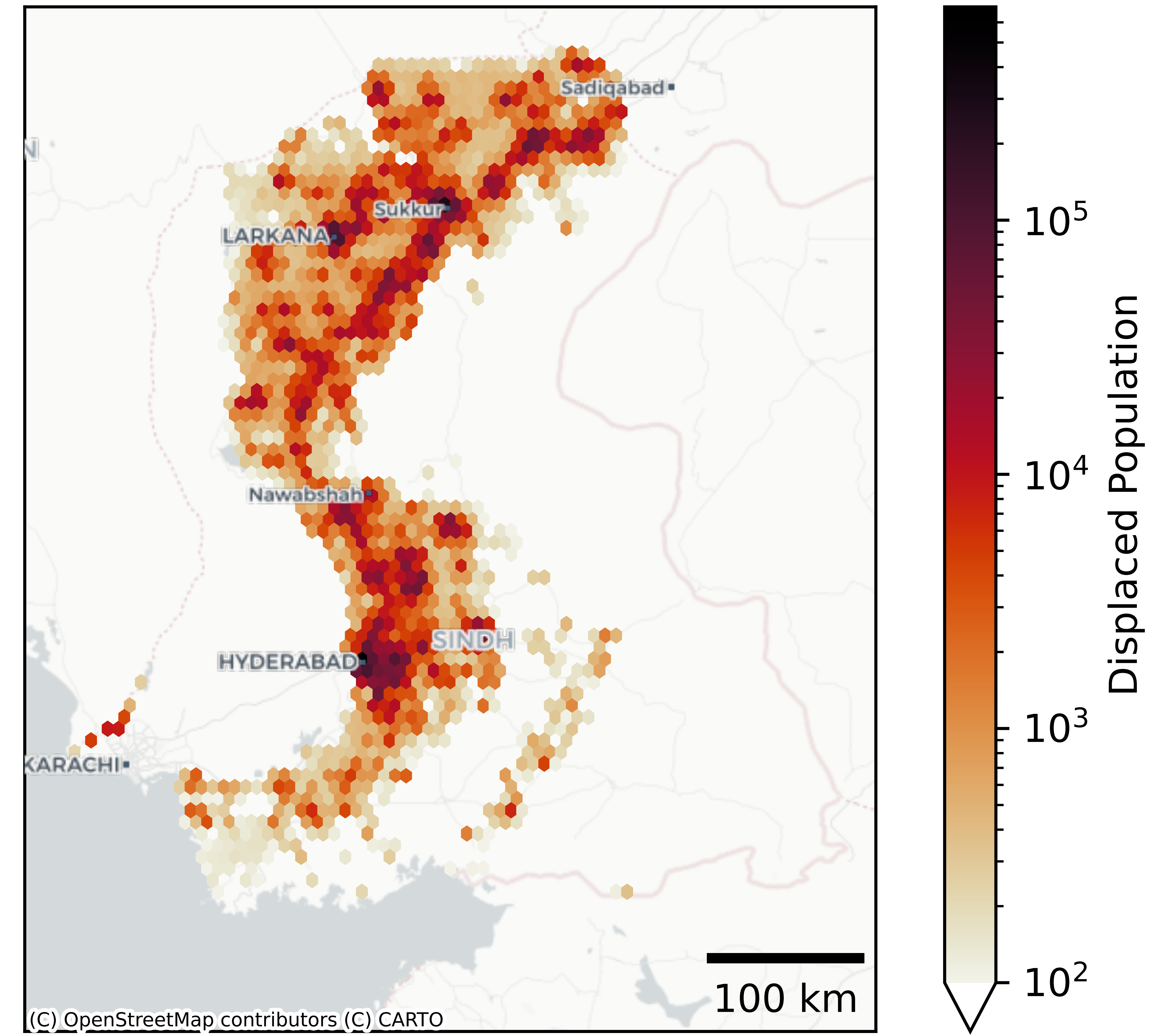
# Calibrated Model Output

Data Source: Provincial Disaster Management Authority (PDMA), Sindh Province

Flooding from 2022-07-01 to 2022-09-30



Model Impact



# Model Sensitivity Analysis

Based on hazard reanalysis data

## Evaluation

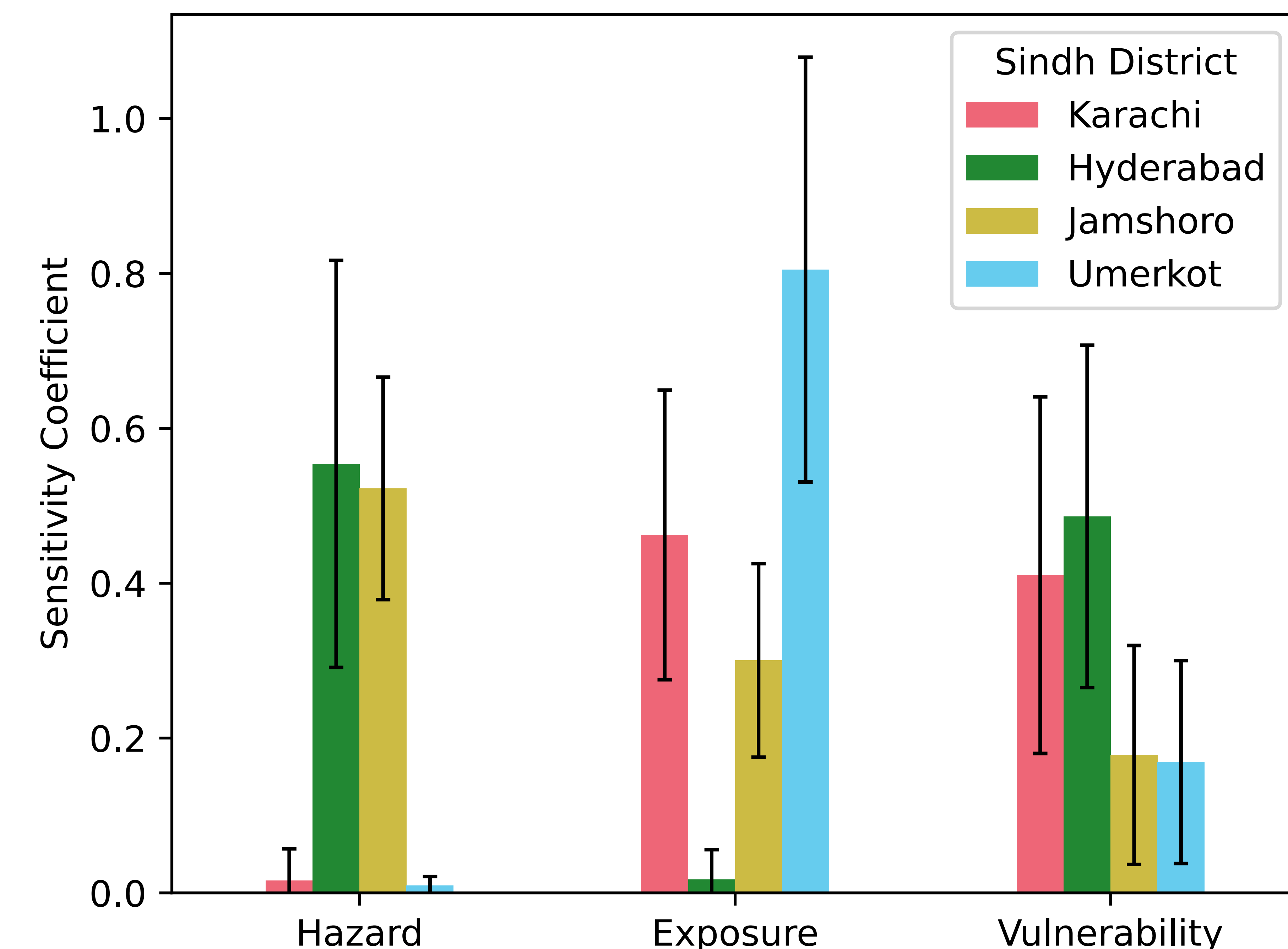
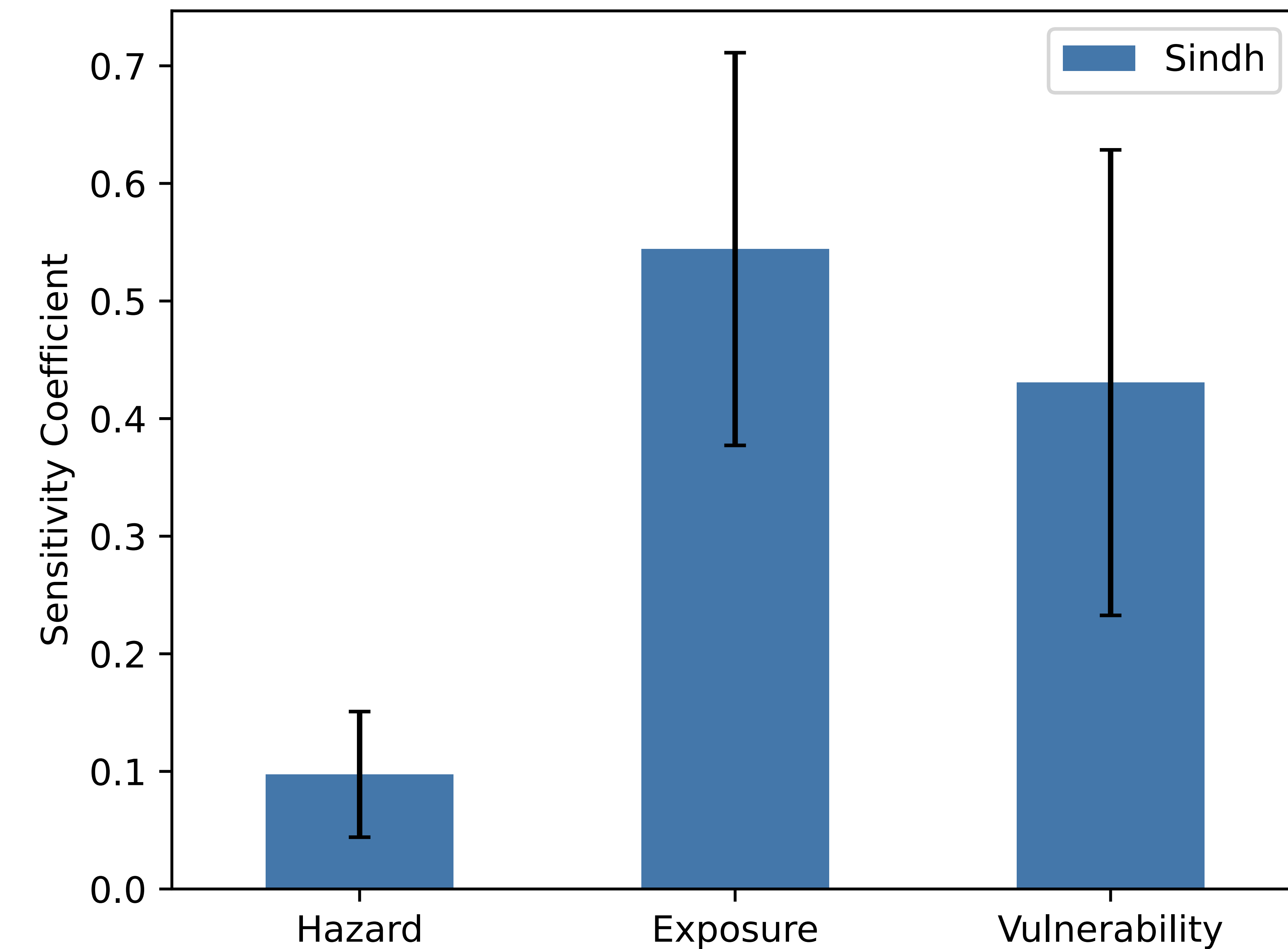
- Sensitivity Coefficient  $S_i$  relates variance w.r.t. parameter  $X_i$  of expected model output  $Y$  to overall model output variance

$$Y = f(X_1, \dots, X_k)$$

$$S_i = \frac{\text{Var}_{X_i}(\text{E}[Y|X_i])}{\text{Var}(Y)} \in [0, 1]$$

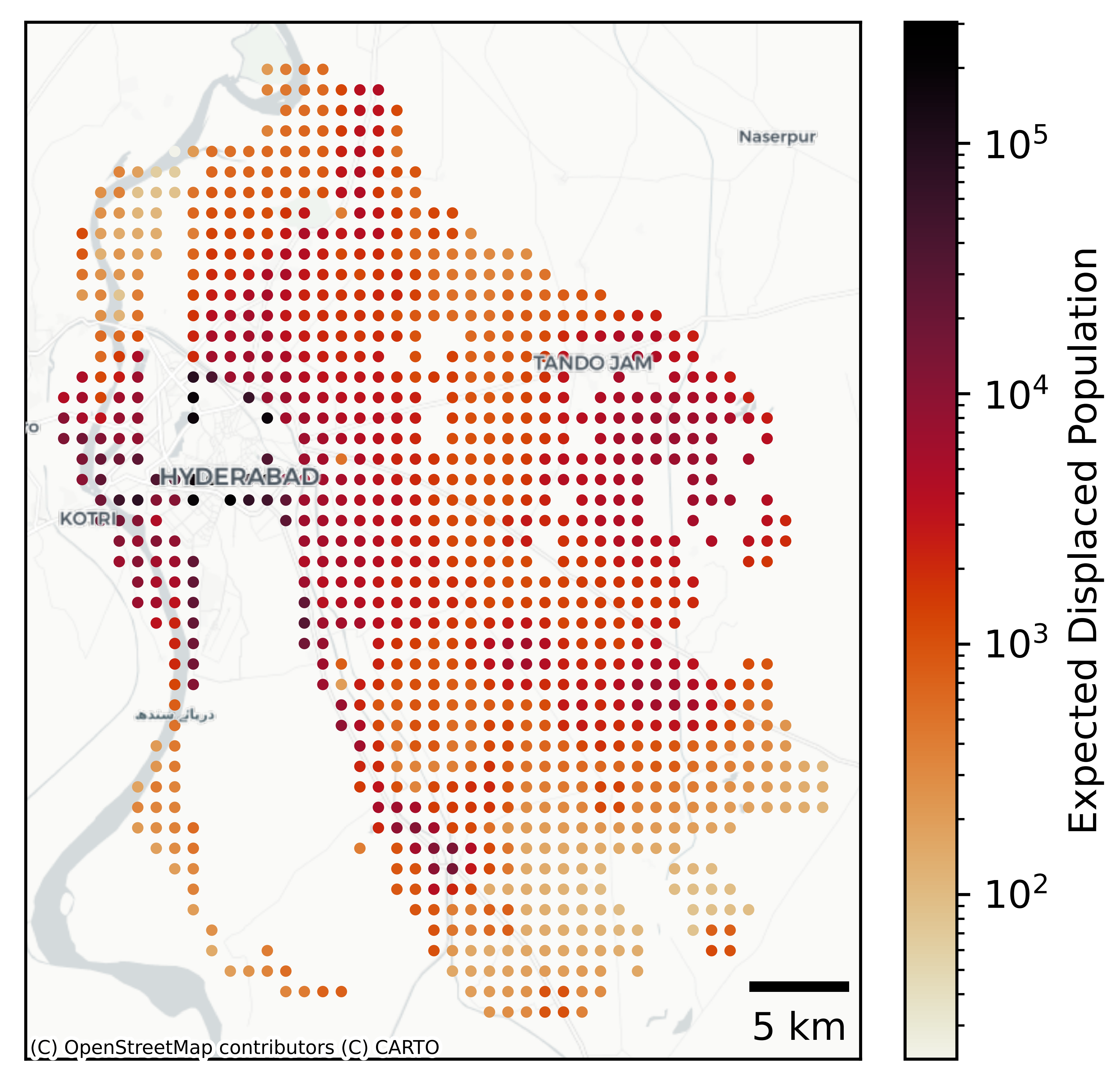
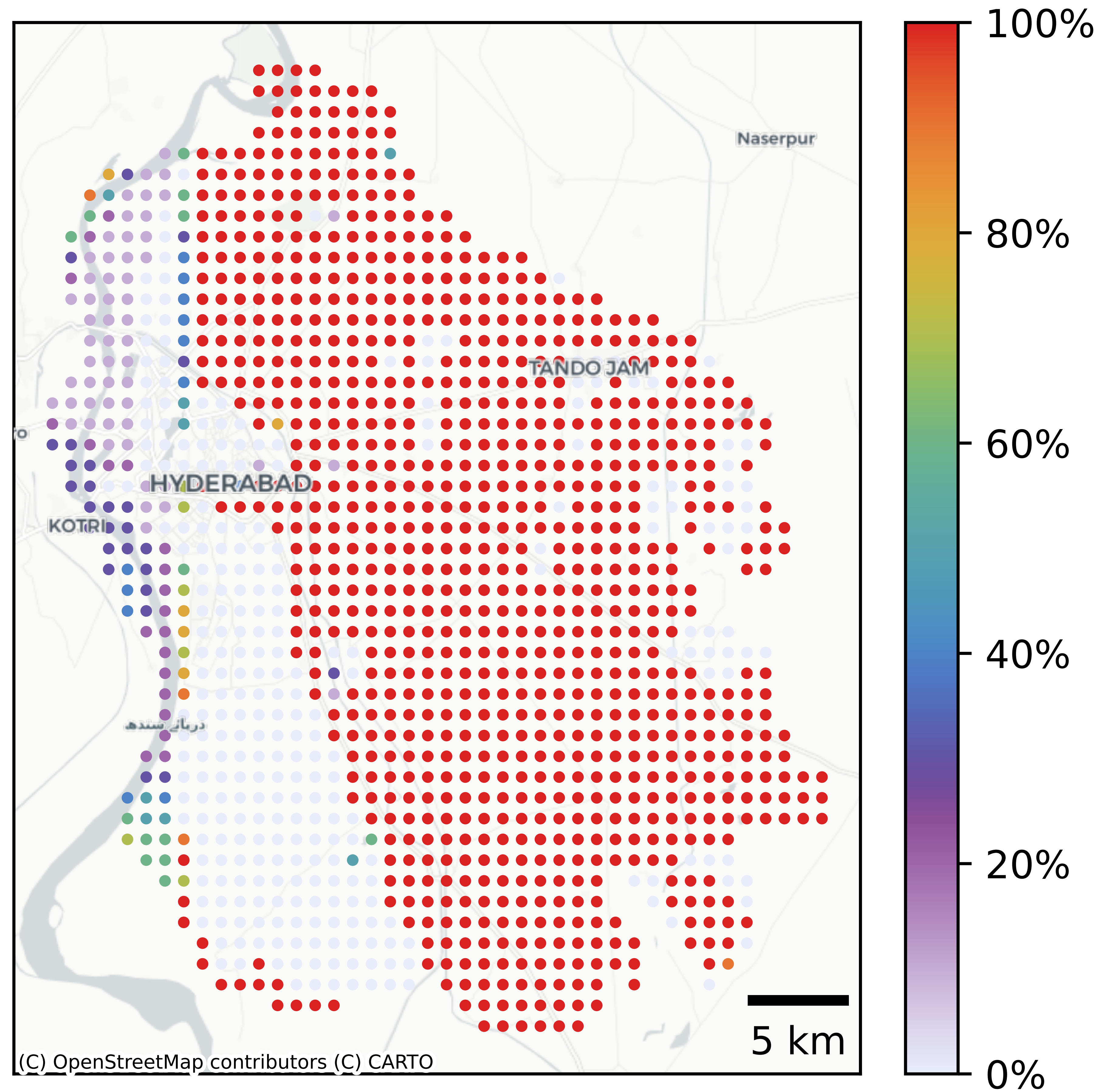
## Results

- Sensitivity to hazard is low when only regarding statistical uncertainty
- Local sensitivity varies strongly



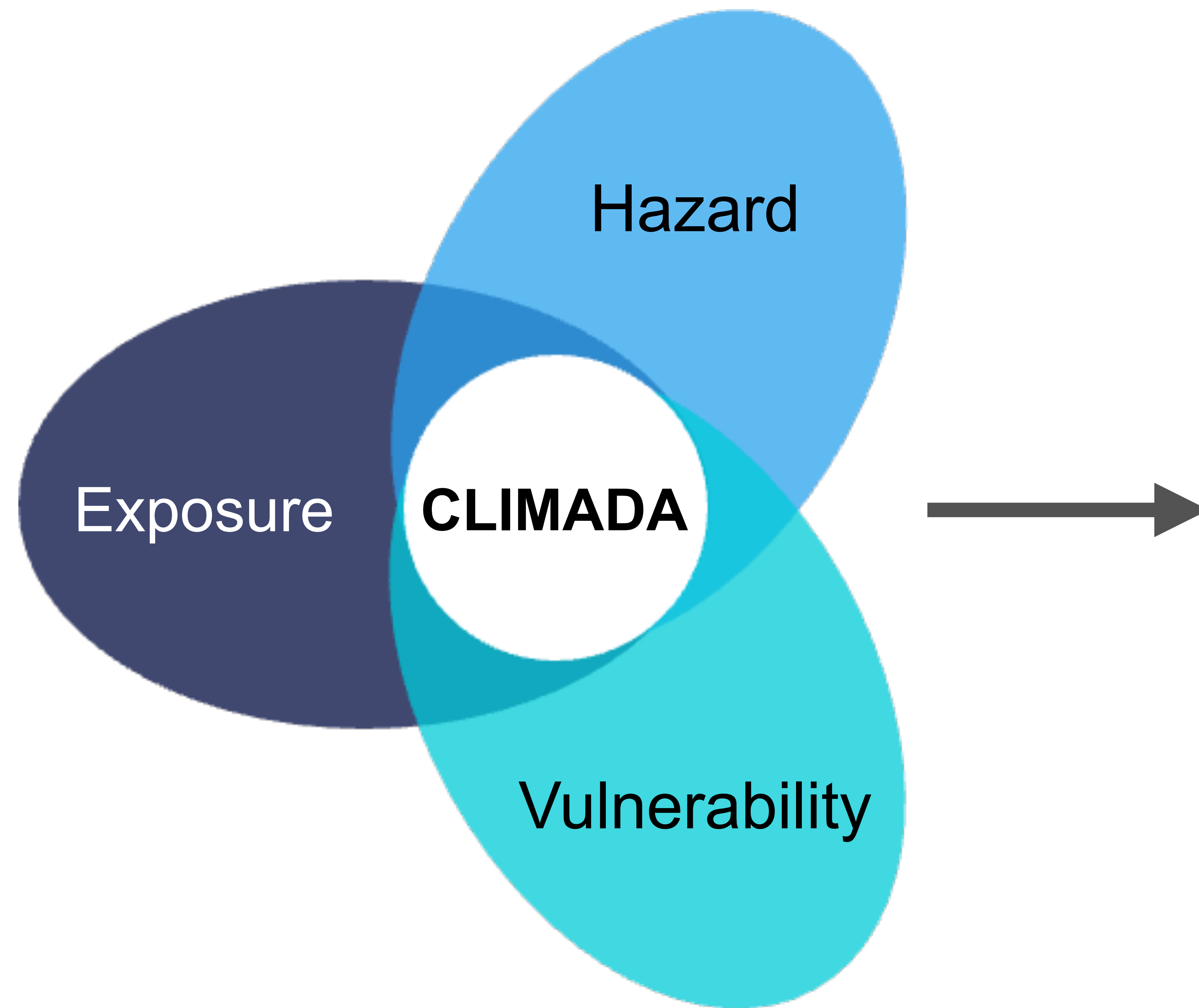
# Model Sensitivity Analysis

## Hyderabad District, Sindh

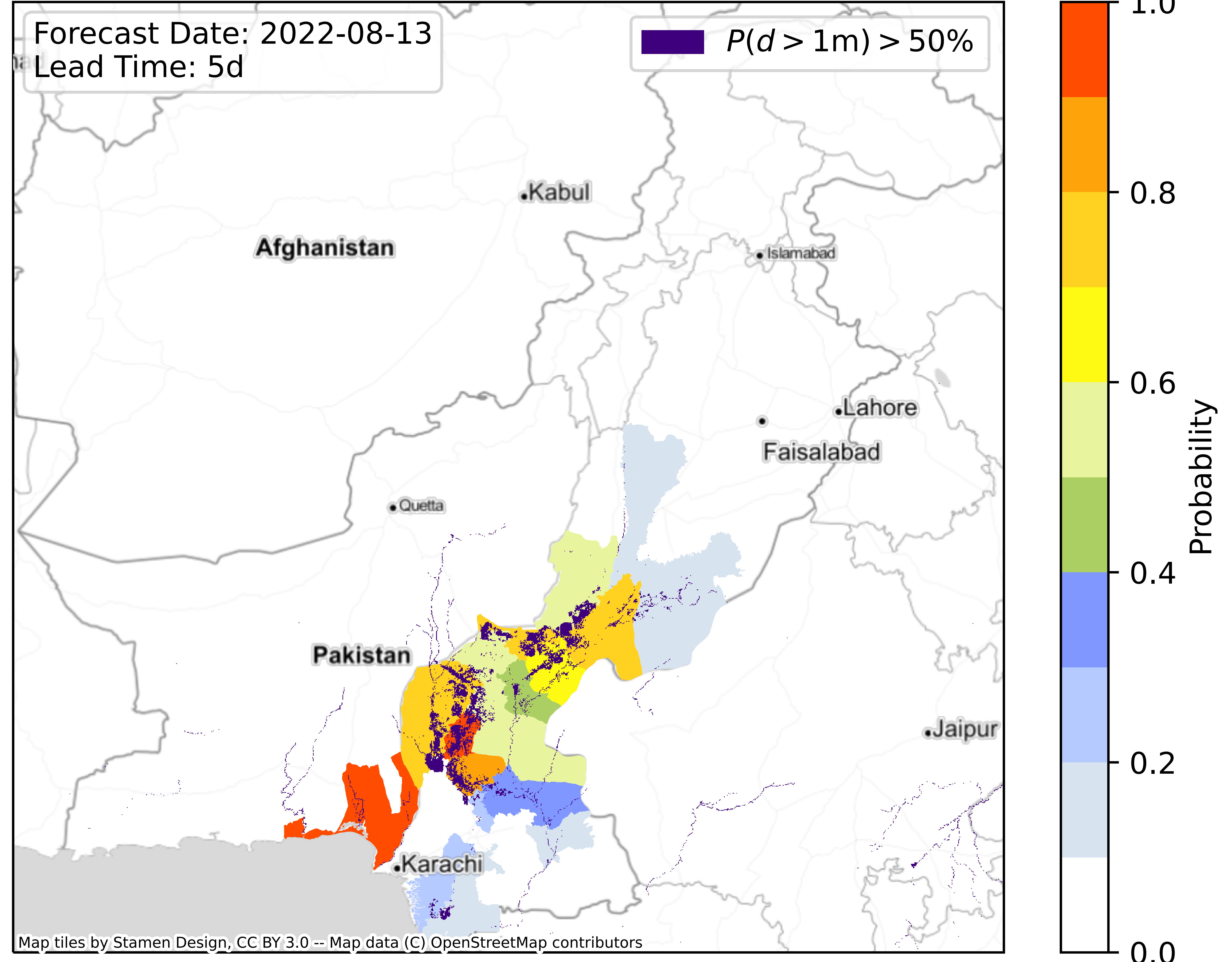


# Outlook: Impact Forecasts

## Considering Forecast Uncertainty



>10% of Population in Danger of Displacement



# Conclusion

## Summary

- We implemented a **river flood impact** model in CLIMADA based on open data
- We can **calibrate** the model to past events and **quantify uncertainties**
- We demonstrated a **proof-of-concept** for globally-consistent flood impact forecasting

## Outlook

- Develop automated **forecast prototype** at MeteoSwiss
- Cooperate with stakeholders to devise **information products** for decision makers

Photo by [Kelly Sikkema](#) on [Unsplash](#)

# References

- Alfieri, L., et al. (2013): GloFAS – global ensemble streamflow forecasting and flood early warning, *Hydrol. Earth Syst. Sci.*, 17, 1161–1175, <https://doi.org/10.5194/hess-17-1161-2013>
- Dottori, F., et al. (2016): Development and evaluation of a framework for global flood hazard mapping, *Advances in Water Resources*, 94, 87–102, <https://doi.org/10.1016/j.advwatres.2016.05.002>
- Scussolini, P., et al. (2016): FLOPROS: an evolving global database of flood protection standards, *Nat. Hazards Earth Syst. Sci.*, 16, 1049–1061, <https://doi.org/10.5194/nhess-16-1049-2016>
- Aznar-Siguan, G. & Bresch, D. N. (2019): CLIMADA v1: a global weather and climate risk assessment platform, *Geosci. Model Dev.*, 12, 3085–3097, <https://doi.org/10.5194/gmd-12-3085-2019>
- Kropf, C. M., et al. (2022): Uncertainty and sensitivity analysis for probabilistic weather and climate-risk modelling: an implementation in CLIMADA v.3.1.0, *Geosci. Model Dev.*, 15, 7177–7201, <https://doi.org/10.5194/gmd-15-7177-2022>
- Gridded Population of the World: <https://sedac.ciesin.columbia.edu/data/collection/gpw-v4>
- NASA Black Marble: <https://blackmarble.gsfc.nasa.gov/>