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The Built-Hazard Interface: A Dynamic Framework for Mapping Hazard Zones

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Abstract:

Since 1980, the United States alone has seen 403 "billion dollar" weather and climate related disasters accounting for 16,918 deaths and over $2.9 trillion in damages (NOAA National Centers for Environmental Information (NCEI) 2025). Climate and weather hazards such as fires, landslides, floods, heat waves, and cold snaps are accelerating in their destructiveness and deadliness due to climate change, development patterns, differential vulnerability, and numerous other human-environmental factors (Schwierz et al. 2010; AghaKouchak et al. 2020; De Sherbinin, Schiller, and Pulsipher 2012; Horton et al. 2016; Buchanan et al. 2020; Iglesias et al. 2021; Guo et al. 2024).

Hazards become disasters through social-environmental interaction that leads to destruction of lives and property. For example, wildland fires can start as a human action such as a cigarette butt tossed to the ground which then ignites a larger natural hazardscape. In addition to event level human causes, the magnitude and destructiveness of hurricanes has been increasing due to anthropogenic climate change (Schoennagel et al. 2017; Lin et al. 2012). Even when humans are not causing the natural hazard event, the expansion of the built environment into hazard prone places are putting more people and property in the path of destruction (Liu et al. 2015; Flores, Collins, and Grineski 2023). The generation of disaster through the interaction of built environment and hazards highlights a need to capture these spaces of interaction as they are situated spatially and as they change through time.

In this paper we propose a new framework for mapping spaces where the built environment and hazard prone areas meet, which we term the Built Hazard Interface or BHI. The BHI framework is a rethinking of how hazards and built environments interact to explicitly account for how people and property are exposed to destructive natural hazards. This BHI framework seeks to measure and map these spaces of heightened exposure at the spatial and temporal scale that both the hazard process and built environment operate at, something currently utilized methodologies do not do well.

We present a testbed analysis on generating these maps for Colorado's 2010 wildland urban interface (WUI), which is a space interaction between flammable vegetation and the built environment (Butler 1974). The WUI presents a clear case where applying the BHI framework can improve our understanding of wildfire exposure through spatio-temporally specific depictions of the hazardscape. To build these maps we developed a methodology leveraging the Clay geospatial foundation model (Clay Foundation n.d.), a pre-trained transformer-based model, which we use to generate a semantic picture of land cover or embeddings. Embeddings are vectors of patterns recognized by the model contained within, in our case, supplied Landsat imagery. We then use these embeddings, in conjunction with the highest resolution data available on the built environment (parcel and building footprint data) and wildfire event data provided by the Monitoring Trends in Burn Severity Dataset (Picotte et al. 2020) to train a LightGBM model on select areas surrounding wildland fires. The trained model was used to map all of Colorado's 2010 BHI for wildland fire.

This testbed analysis will pave the way for a broader application of these methods to other hazards and larger geographic areas. The Built Hazard Interface mapping framework will have the potential to be used in numerous user-facing applications such as public facing real-estate portals (e.g., Zillow) to inform individuals of their risk or by developers/governments to rapidly generate maps to test the impact of new development on hazard exposure. Our central claim is that our BHI methodology can be a more flexible and location specific solution to mapping the interaction between the environments we build and the hazards that threaten them.

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