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Empirically-Derived Urban Morphological Typologies for Heat Vulnerability Assessment

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Addressing high-temperature exposure in cities requires understanding multiple environmental dimensions, with urban morphology playing a central role. Urban morphology—which include building density, height, and arrangement—significantly influences microclimatic conditions and opportunities for adaptation. A widely used framework for studying these relationships is the Local Climate Zones (LCZ), which provides a solid theoretical foundation for understanding urban climate variations. However, LCZ categories are often idealized and may not accurately reflect the complexity of real-world environments, particularly when attempting to describe both morphological and thermal properties simultaneously.

Although urban form and thermal behavior are inherently interrelated, similar urban forms can exhibit different thermal responses depending on factors like vegetation cover, impervious surfaces, and building materials. To better represent real-world variability, separating morphological classifications from thermal characteristics allows for an analysis that accounts for these differences.

To address these challenges, we develope an approach that generates empirically derived urban morhophological types while maintaining connections to LCZ categories. Our tool systematically classifies urban morphological types for fine-grained, nationwide assessments, enabling consistent comparisons across diverse Dutch urban residential areas. This approach uses readily available geospatial data and applies unsupervised machine learning techniques to identify urban morphological typologies. By standardizing the classification process into 100 x 100 m grid cells from Statistics Netherlands, our method provides a consistent spatial and temporal framework that transcends changing administrative boundaries.

Our approach helps streamline vulnerability analysis by facilitating the intersection of multiple environmental and social dimensions. We demonstrate the tool's utility through an explorative analysis that identifies which socio-economic groups reside in neighborhoods with high heat exposure, considering both morphological types and additional factors influencing heat exposure. This tool provides urban planners and researchers with an empirically-grounded framework for identifying priority areas in existing settlements for scalable adaptation interventions across different urban contexts.