MAPPING URBAN NUISANCE FLOODING USING SATELLITE IMAGERY AND FLOOD SENSOR NETWORKS

SOUTHEAST TEXAS
URBAN INTEGRATED FIELD LAB

Understanding the where and why of flooding in SETx

WHY NOW?

Urban flooding in Southeast Texas is driven by flat terrain, intense rainfall, poorly drained soils, and expanding impervious surfaces. While extreme flood events receive substantial attention, frequent pluvial nuisance flooding produces cumulative impacts on transportation, infrastructure, and public safety. Traditional floodplain maps often fail to represent small-scale, short-duration, and recurring urban flooding, limiting their usefulness for early warning systems and local mitigation planning.

WHAT WE DID

This approach brings together satellite images and local flood sensors to better understand where nuisance flooding happens and where it is likely to happen again. Satellite data are used to spot areas where water collects after heavy rain. These observations are checked against rainfall information and local flood sensors to confirm that the water seen from space reflects real flooding on the ground. Detailed elevation maps help identify low-lying areas where water tends to pool and drain slowly, and repeated flooding over time is used to highlight places that have ongoing problems. The method reveals not only where nuisance flooding occurs, but also why some areas are more vulnerable than others. The results provide practical information that communities can use to improve flood early warning, guide infrastructure upgrades, and better prepare for future storms.

WHO WAS INVOLVED?

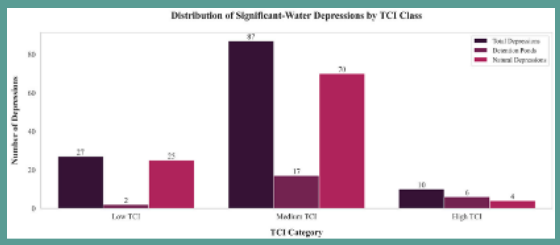
Ground-based flood sensor networks operated by the Jefferson County Drainage District, Southeast Texas Flood Control District, and Lamar University provided critical validation data for both radar detection and susceptibility modeling. A Local Community Task Force composed of engineers, government officials, citizens, and emergency management officials contributed local knowledge and identified known flood-prone areas, ensuring strong alignment between model results and observed flooding behavior.

FINDINGS

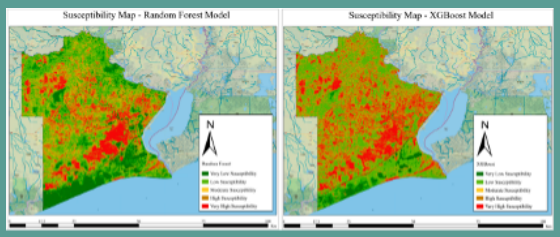
• Terrain and drainage characteristics are primary controls on flood behavior, as low elevations, low gradients, poorly drained soils, and natural depressions consistently demonstrate higher water retention, whereas engineered detention features generally perform as intended and can be distinguished through their controlled storage response. A total of 99 flood prone natural depressions were identified in Beaumont TX---among these, 74 depressions were identified as priority nuisance flood hotspots.

• Satellite-derived flood detection shows strong agreement with in-situ measurements, with radar-identified water presence closely matching flood sensor records, confirming the reliability of satellite imagery for identifying areas of sustained surface flooding following rainfall (100% precision, ~71% accuracy).

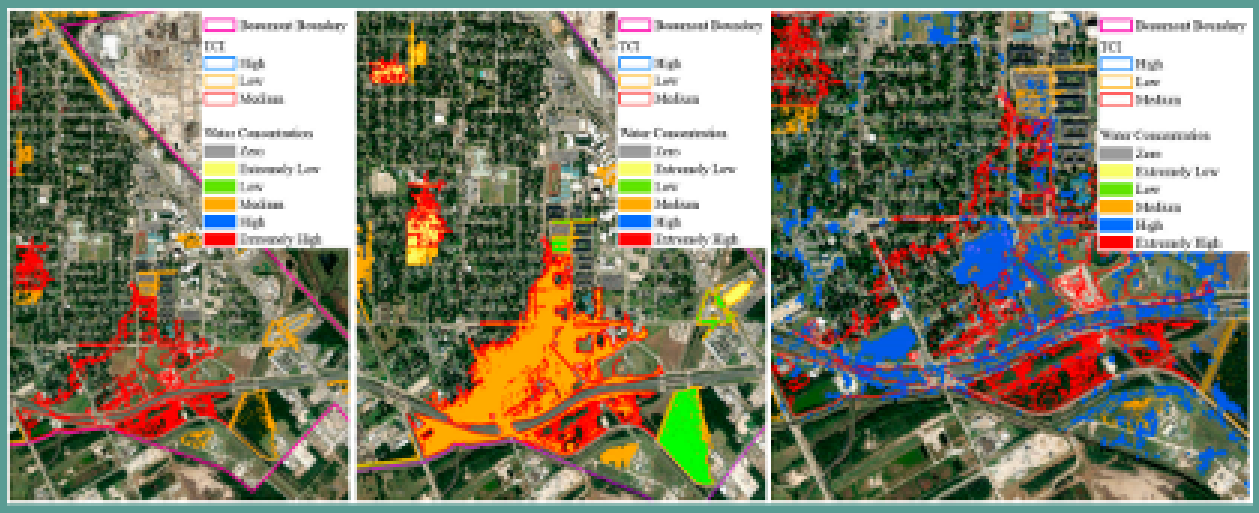
• Advanced susceptibility modeling provides improved flood characterization, with machine-learning-based approaches outperforming traditional statistical methods by more effectively capturing the nonlinear interactions among topography, land cover, soils, precipitation patterns, and drainage infrastructure. Machine learning models performed better than the statistical method, with XGBoost showing the highest accuracy (AUC ≈ 0.92), followed by Random Forest. The most important factors controlling flooding were low elevation, flat slope, and high Topographic Wetness Index (TWI).



Distribution of water concentration classes and Detention ponds in medium to extremely high-water pixel depressions



Flood Susceptibility maps of Jefferson County, Texas.



Integration of TCI Map and High Water concentrated areas in Beaumont, TX.

MORE ABOUT SETX-UIFL

The Southeast Texas Urban Integrated Field Lab (SETx-UIFL) is one of four projects funded in 2022 by the U.S. Department of Energy to study how climate, environment, and urban changes affect cities. A team of over 80 researchers from UT, Lamar University, Texas A&M, Prairie View A&M, Oak Ridge National Lab, and Los Alamos National Lab has collected data and conducted modeling across hazards including flooding, hurricanes, heat stress, and air quality. Our Why: Southeast Texas faces numerous hazards, yet smaller communities like this one have often felt forgotten compared to larger cities. The SETx-UIFL was designed to explore the complex dynamics of disaster vulnerability for this economically and culturally vibrant region. We believe Southeast Texas is a bellwether for the entire Gulf Coast, and an exemplar for strategies that protect people and places. We hope this effort supports your path toward lasting resilience.

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