Spatial Analysis of Oil and Gas Pipeline Accidents in Texas

Conducted a comprehensive spatial analysis of historical pipeline accidents, enabling an evaluation of the potential human and environmental exposure within Texas.

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Course:
GY7707: Geospatial Data Analytics

Technologies & Skills Used

✅ R (sf, tidyverse,terra and mapsf) **|** ✅ GIS **|** ✅ Spatial analysis **|** ✅ Spatial statistics, Hotspot analysis (Local Moran's)

Data Sources & APIs: U.S. DOT Pipeline and Hazardous Materials Safety Administration dataset, U.S. Census Bureau (tidycensus package), Texas Water Development Board GIS data

Project Overview

This study investigates the spatial distribution of oil and gas pipeline accidents in Texas, identifying high-risk areas and assessing potential human and environmental exposure. By leveraging geospatial analysis techniques, the project provides insights into accident hotspots, population vulnerability, and environmental risks associated with pipeline failures.

Key Objectives

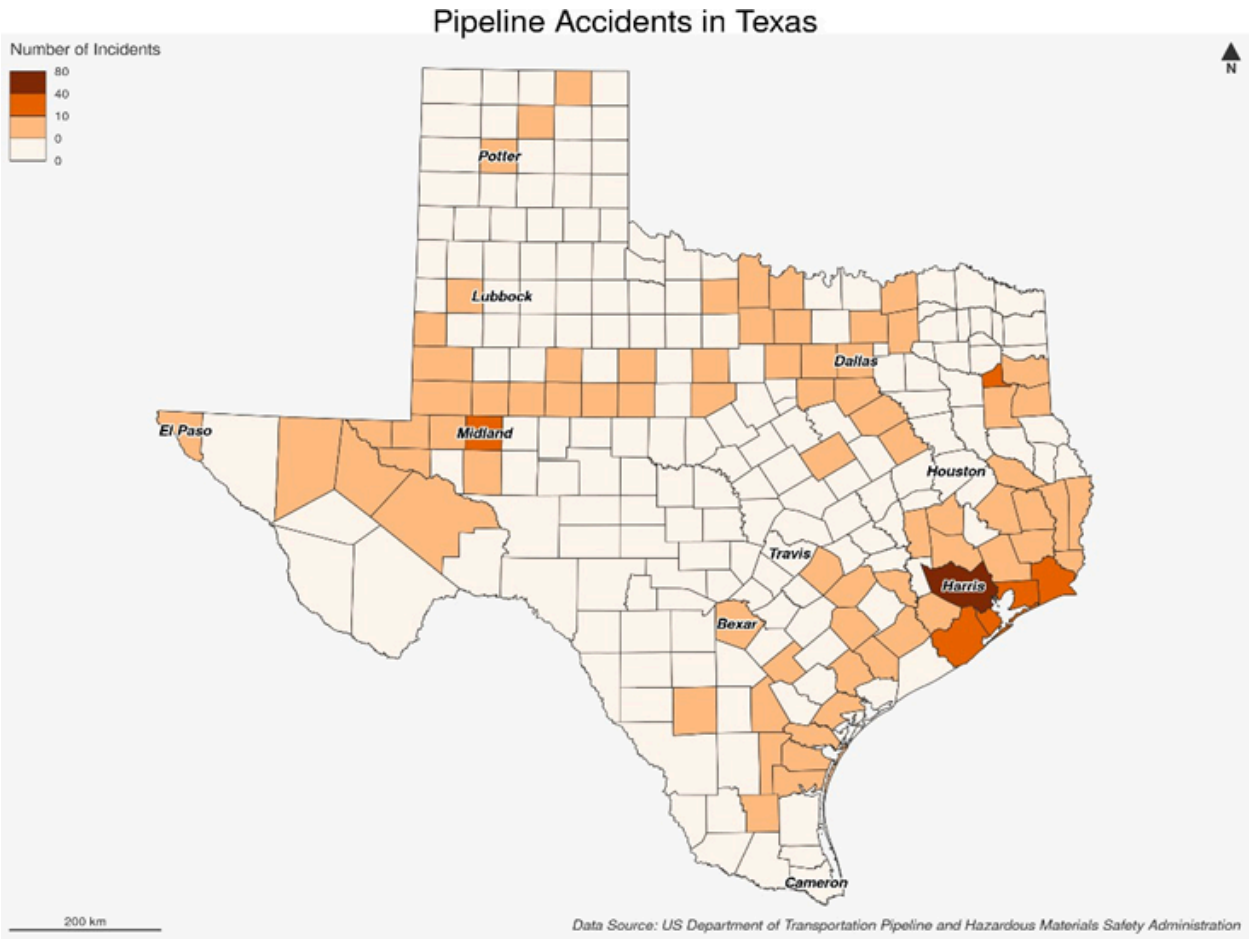
- Identify spatial patterns and clusters of pipeline accidents using Local Moran's I analysis.
- Assess human exposure by analyzing population distribution within accident proximity zones.
- Evaluate environmental risks by examining the overlap between pipeline accident sites and major rivers.

Data & Methodology

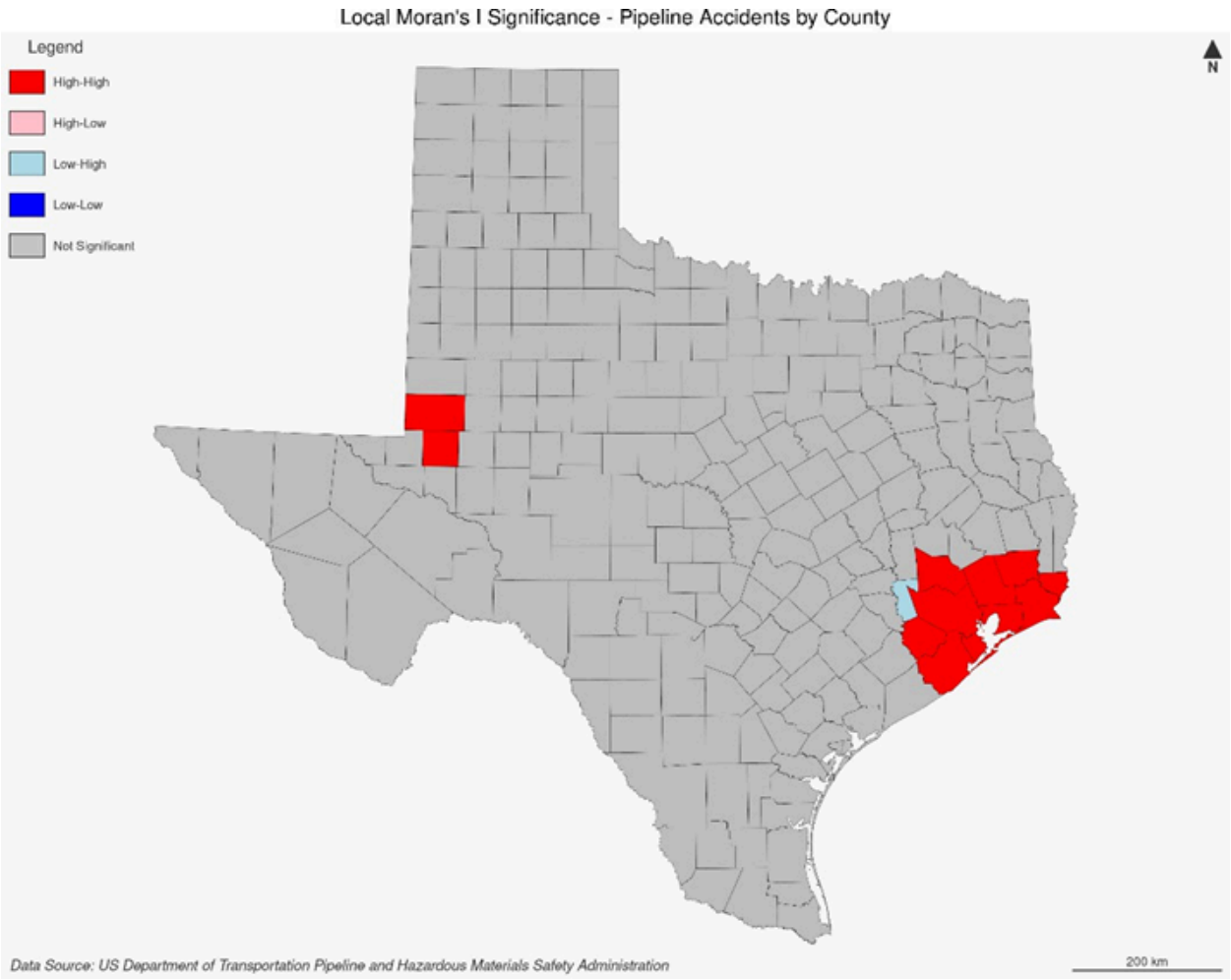
- Data Sources:
    - Pipeline accident data (1986–2017) from the U.S. Department of Transportation.
    - Population data from the U.S. Census Bureau.
    - River and boundary data from the Texas Water Development Board and tigris library in R.
- Spatial Analysis Techniques:
    - Hotspot analysis (Local Moran's I) to detect high-risk accident clusters.
    - Proximity analysis (2.5 km buffer zones) to assess human exposure.
    - Environmental impact assessment based on river proximity to accident sites.

Key Findings

- High-risk counties: Harris, Midland, Jefferson, Chambers, and Galveston counties had the highest accident densities, correlating with dense pipeline networks.

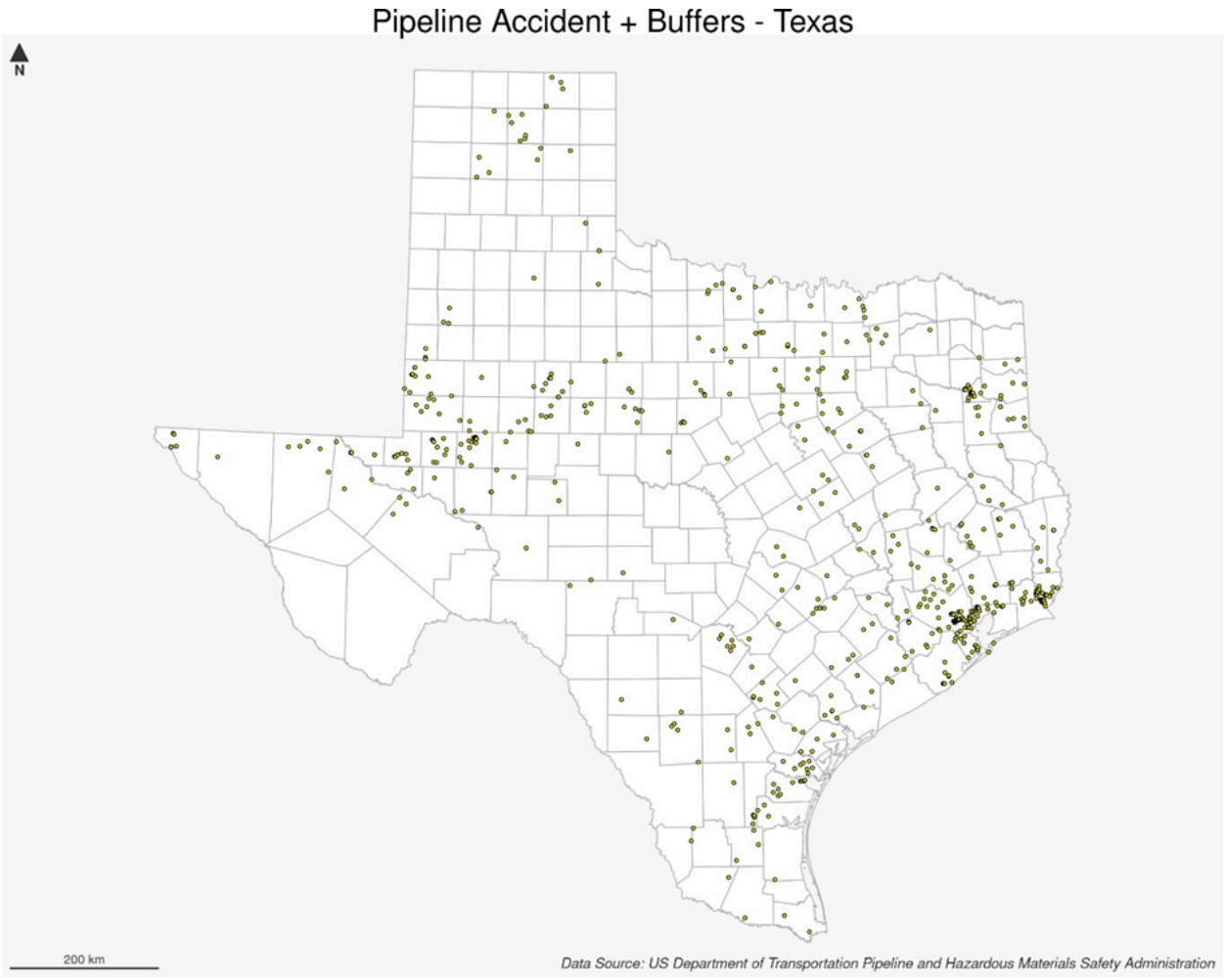


This map shows the pipeline accident hotspots in Texas based on Local Moran's I



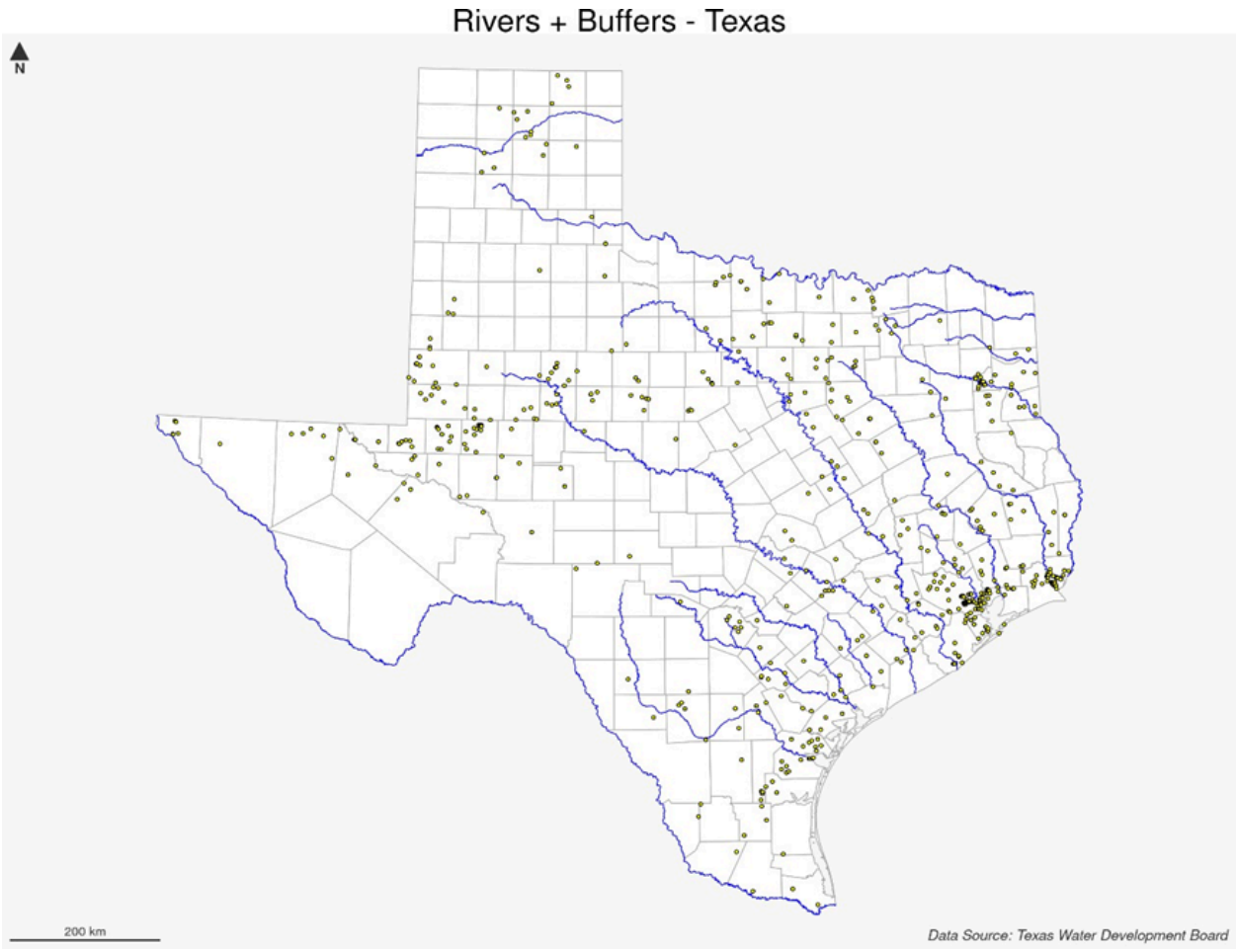
- Human exposure: Approximately 2.8 million people reside within high-risk zones, increasing their vulnerability to pipeline accidents.

This map shows the buffer zones of 2.5 km around pipeline accident locations.



- Environmental impact: Major rivers intersecting with accident-prone areas pose significant contamination risks.

This map illustrates the buffer zones of 2.5 km around rivers.

- 

Impact & Applications

This study provides critical insights for policymakers, environmental agencies, and urban planners to enhance pipeline safety, improve risk mitigation strategies, and protect human and environmental health. The results can inform regulations and emergency response planning for future pipeline infrastructure projects. Overall, this study demonstrates the effectiveness of using R and spatial analysis in addressing real-world problems. R provides extensive libraries such as sf, tidyverse, and mapsf for efficiently analyzing spatial data, enabling detailed and accurate assessments.