Post-Tornado Roadway Debris Detection from Satellite Images: An Integrated GIS and Image Processing Approach

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INTRODUCTION

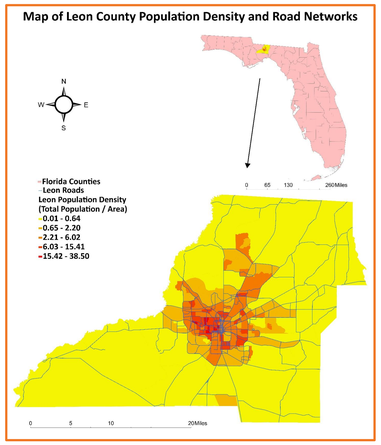
- Natural hazards cause significant damage to infrastructure and properties and take human lives. From 1980 to 2019, natural hazards have cost the U.S. an estimate of $1.75 trillion in damages (NOAA 2020) making it necessary to study their impacts on infrastructure and communities at detailed spatial scales.
- As such, there is a need to provide timely and efficient information regarding the severity and extent of damage of tornadoes debris to local governments to support rescue and recovery operations, and emergency planning and management

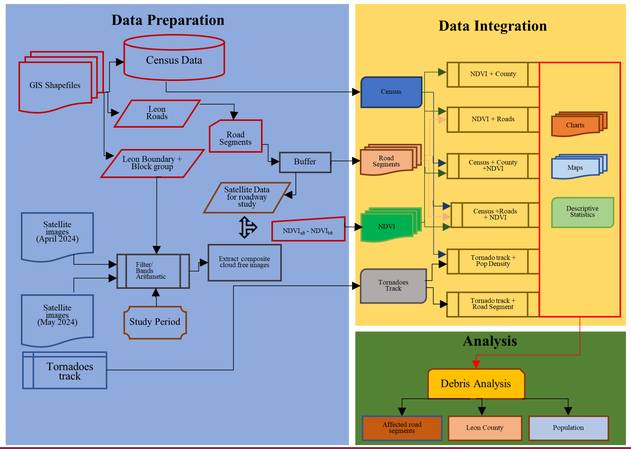
Literature Review

- Several researchers have used LiDAR, Digital Airborne Sensors, GIS, CNN, Laser Scanner, Landsat Thematic Mapper, UAVs, to assess tornado debris.
- RS indices used to assess post-disaster vegetation include Normalized Difference (NDVI), Soil-adjusted (SAVI), Enhanced (EVI), Advanced (AVI).

Our Contributions

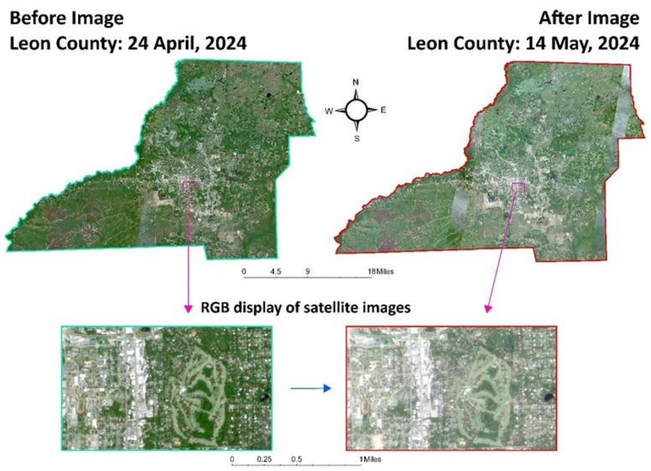
- Develop of a macro-level approach to assess the impact of post-disaster vegetative debris on roadway segments using Geographic Information Systems (GIS) and image processing techniques.
- Investigate the impacts on roadway accessibility and population density.

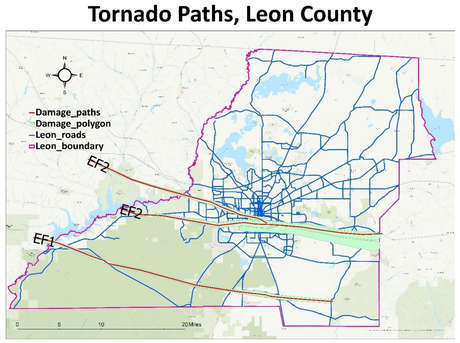




METHODOLOGY

- The data source for the satellite images used in this research is Norway's International Climate & Forests Initiative (NICFI), hosted by Planet. For this study, the RGB (red-green-blue) and NIR (Near-infrared) bands with a 3-meter resolution were utilized, where red is band 3, green is band 2, blue is band 1, and NIR is band 4.
- The analysis concentrated on the county's roadway segments. Images from April 24, 2024, and May 14, 2024, were obtained. The roadway shapefile was segmented and buffered to obtain a 10 feet distance from the roadway edges and used to extract NDVI values.



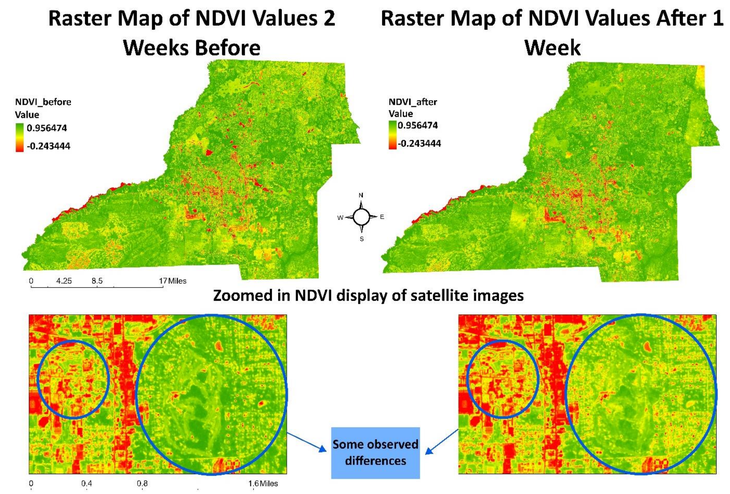


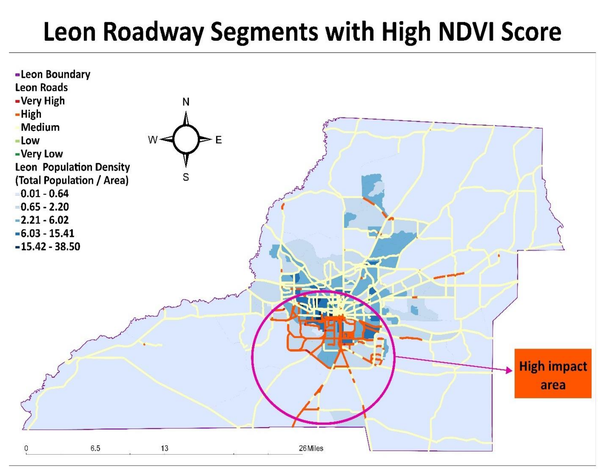
$$NDVI = \frac{\rho_{nir} - \rho_{red}}{\rho_{nir} + \rho_{red}}$$

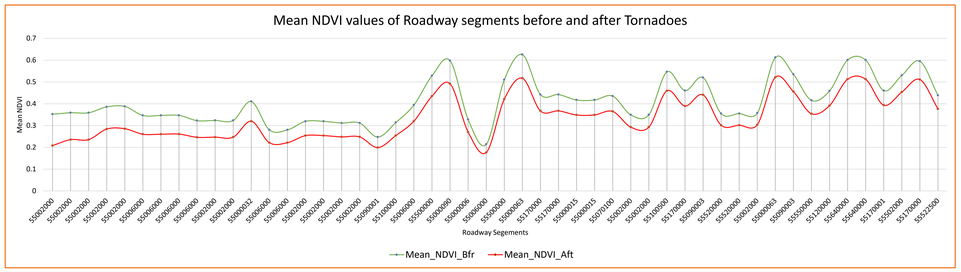
$$\Delta NDVI = \frac{NDVI_{aft} - NDVI_{bfr}}{NDVI_{bfr}} * 100$$

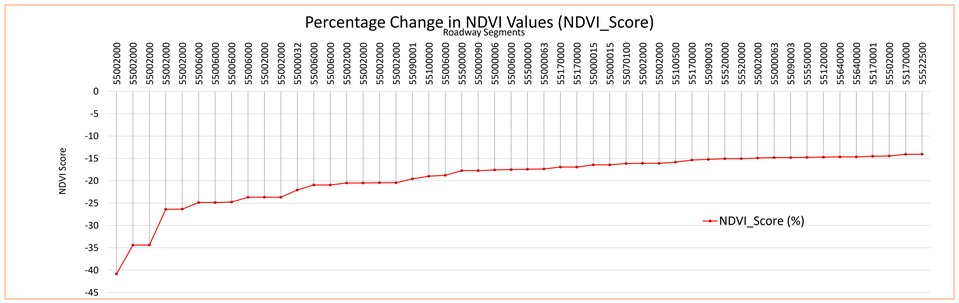
RESULTS

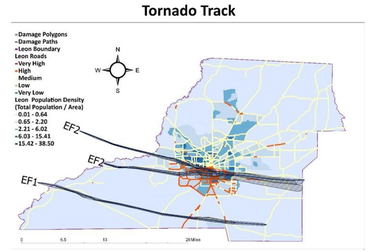
- Out of the 1,505 roadway segments, 44 fell within very high debris zone, 565 fell within high debris zone, 850 fell within medium debris zone, and 46 low to very low debris zone.
- Affected road segment lane count show that 4 % of the road segments that fell in the very high debris zones were 3 lane roads, 39% were 2 lane roads and the remaining 57% were single lane roads. For those within the high debris zone, less than 1% were 4 lane roads, 3% were 3 lane roads, 37% were 2 lane roads, and 59% were single lane roads.

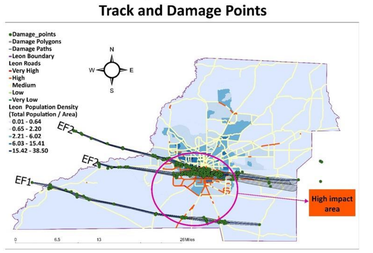












CONCLUSIONS

- The study presented a detailed satellite-based debris assessment to determine areas and roadway segments within the Leon County with high volumes of debris based on the impact of 2 EF-2 and 1 EF-1 tornadoes.
- The analysis was conducted on the county's roadway segments using satellite images from April 24, 2024, and May 14, 2024.
- The central parts of Leon County have the highest population density since the City of Tallahassee is in that area.
- The NDVI scores of the roadway segments in the county before and after the tornadoes were assessed with a focus on the population density.
- Findings were validated with the Tornado track and damage points obtained from the NOAA.
- The proposed approach in this paper can provide state and local agencies an expeditious way to identify these locations and respond accordingly.

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