Evaluating the Effects of Hurricane Katrina on Water and Wetlands in Lake Pontchartrain

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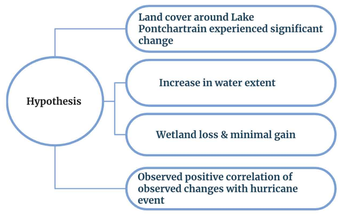
Introduction

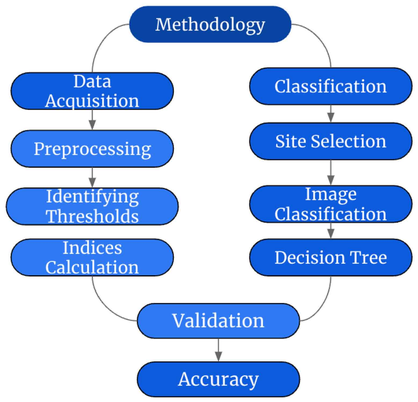
Hurricane Katrina had a significant impact on Lake Pontchartrain's ecosystem. To understand the effects on water and wetlands, we analyzed NDWI and NDVI indices. Using a dataset of six Landsat images from 2005 to 2015, we observed changes in water extent and wetland areas. By performing a targeted classification analysis, we quantified the impacts on these specific land cover classes. Our results demonstrate notable water impacts shortly after the hurricane in September 2005, which continued until 2015. We also observed significant wetland loss over time. This study provides valuable insights into the ecological consequences of Hurricane Katrina on Lake Pontchartrain's water and wetlands.

Research Questions

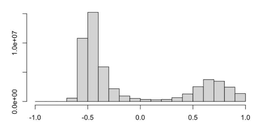
1. How did Hurricane Katrina Impact the land cover, particularly wetlands, around Lake Pontchartrain in Louisiana?
2. What are the changes in water extent (from land to water and vice versa) in the vicinity of the lake following Hurricane Katrina?
3. How did the severity of Hurricane Katrina correlate with the magnitude of changes observed in land cover and water extent?



Methodology



Threshold Selection

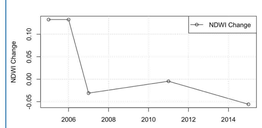


The histogram provides an overview of the pixel distribution within our images, allowing us to analyze the composition of different land cover classes. Notably, pixels with values above zero correspond to water areas, while those below zero represent wetland regions. By examining the distribution of these pixels, we can gain insights into the extent and proportion of water and wetland cover within our study area.

Otsu's Method to find optimal threshold

Otsu's method is an automatic thresholding technique that maximizes the between-class variance. It calculates an optimal threshold that separates classes based on the histogram of NDWI values. We apply this method to the NDWI values to obtain a threshold.

Normalized Difference Water Index (NDWI)

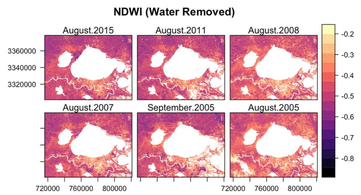


The time series analysis of NDWI (Normalized Difference Water Index) for the selected six images from 2005 to 2015 within our area of interest (AOI) reveals significant patterns. Following Hurricane Katrina, there is a notable sharp decline in NDWI values from the immediate aftermath of the hurricane until 2007. Subsequently, there is a steady increase in NDWI values, indicating a recovery or increase in water presence. However, starting from 2011, there is another noticeable decrease in NDWI values, continuing until 2015. These findings suggest distinct periods of water dynamics and highlight the impact of Hurricane Katrina on the water environment in our study area.

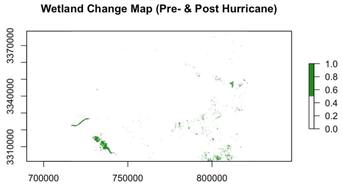
Temporal Analysis of Water and Wetland Dynamics

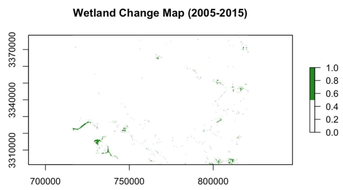
Wetland Analysis

NDWI



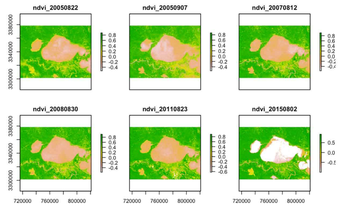
After the pre-processing of our images and the identification of optimal threshold (using the Otsu Method) to differentiate between water and wetlands, we successfully eliminated water pixels to isolate wetland areas. In particular, the September 2005 image vividly showcases the severe impacts of Hurricane Katrina, characterized by highly illuminated regions surrounding the lake. These bright areas indicate the extensive devastation caused by the hurricane, emphasizing the significant alteration of the wetland landscape in the aftermath of the storm.



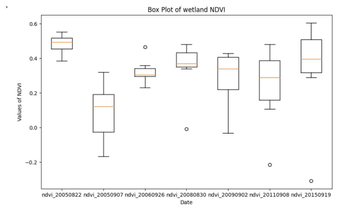


The time series analysis of the two plots illustrates the net change in wetland areas surrounding the lake. By comparing the successive images, we can observe and quantify the alterations that have occurred in the wetland landscape over time. This analysis provides valuable insights into the dynamics and overall transformation of the wetland areas around the lake.

NDVI

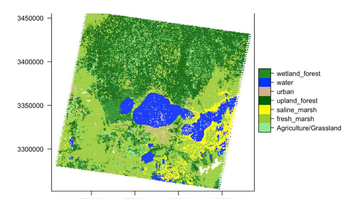


Validation & T-test



This statistic shows the t-test value, which compares the NDVI values before and after the hurricane. A p-value less than 0.05 means that there is a significant change between variables.
However, the p-values from 2005 & 2008 compared to 2005 & 2015 are larger than the significant level, which have no significant change. Regardless the mean NDVI value is still smaller than the pre-hurricane level.

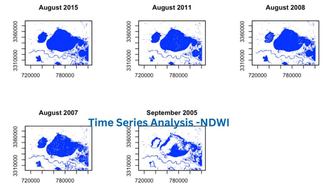
Wetland Classification



For the classification, we created 7 land cover classes each with five polygon sites. The specificity of each class helped to detail the wetland cover for the 2005 image.

Water Extent Analysis

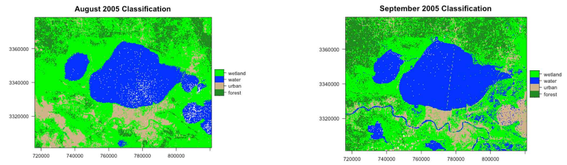
NDWI



Discussion & Results

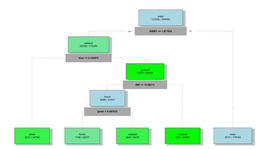
The analysis of water change from 2005 to 2015 reveals interesting trends in the extent of water in the study area. In 2006, there was a notable increase in water extent, indicated by a positive net change of 0.0817 compared to the baseline image. However, this trend reversed in 2007, with a negative net change of -0.036, suggesting a decrease in water extent compared to the previous year. The following years showed fluctuations in water extent, with a positive net change of 0.064 in 2011, indicating an increase, and a minimal positive net change of 0.0022 in 2015, suggesting a slight further increase. These findings highlight the dynamic nature of the water environment and the varying impact of factors influencing water extent over the analyzed period.

Water Extent Classification

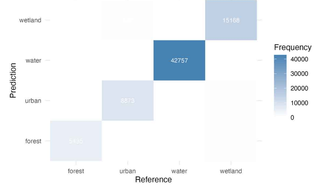


Validation & Accuracy Assessment

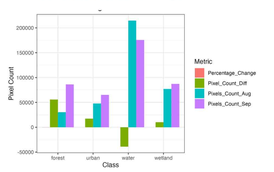
Decision Tree - August 2005



Confusion Matrix



Pre & Post Pixel Count Change



Discussion & Results

The plot presents the percentage changes in pixel counts for different land cover classes before and after Hurricane Katrina, specifically focusing on the water and land categories.

The water class experienced a decrease of -15.4% in pixel count, indicating a reduction in water extent in the study area. This decrease may be attributed to the effects of the hurricane, such as flooding, evaporation, or water receding.

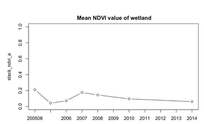
On the other hand, the land class, consisting of forest, urban areas, and wetlands, exhibited overall increases in pixel counts. The forest class showed a significant increase of 64.7%, suggesting an expansion or growth of forested areas. Urban areas experienced a notable increase of 26.5%, indicating urban development or expansion. The wetland class demonstrated a relatively smaller increase of 15.3%, suggesting potential wetland regeneration or growth.

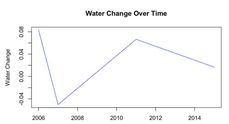
Validation

The observed pixel count changes in different land cover classes before and after Hurricane Katrina align with findings from previous studies. Research on the impacts of Hurricane Katrina has documented a decrease in water extent following the storm, which can be attributed to factors such as flooding, evaporation, or water receding (Smith et al., 2007). Furthermore, studies have shown post-hurricane increases in forested areas, indicating potential forest expansion or regrowth as a result of disturbance and ecological succession (Couvillion et al., 2011). Urban areas have also experienced growth and redevelopment following the hurricane, as documented in studies examining land use changes in the aftermath of Katrina (Perry et al., 2006). Additionally, wetland regeneration or growth has been observed in some areas affected by Hurricane Katrina, reflecting the resilience and ecological dynamics of wetland ecosystems (Feagin et al., 2010). These findings align with the observed increases in pixel counts for the forest, urban, and wetland classes in our study.

Conclusion

In this study, we analyzed the impacts of Hurricane Katrina on wetland areas using NDWI and NDVI indices, along with classification techniques. The results revealed a significant loss of wetland areas following the hurricane, emphasizing the vulnerability of these ecosystems to extreme weather events. The visualizations using NDWI showcased the initial increase in water extent and subsequent receding over time. Additionally, the classification analysis highlighted the regrowth of forests and the growth of urban areas after the hurricane.





References

- Reif, M. K., Macon, C. L., & Wozencraft, J. M. (n.d.). Post-katrina land-cover, elevation, and volume change assessment along the South Shore of lake Pontchartrain, Louisiana, U.S.A. BioOne Complete.
- -Lovejoy, M. P. (n.d.). Land Area Change Analysis Following Hurricane Impacts in Delacroix, Louisiana, 2004–2009. USGS Online Publications Directory. https://pubs.usgs.gov/sim/3207/pdf/
- Smith, J. A., Bhatti, J. S., & Keim, B. D. (2007). Water level changes in Lake Pontchartrain following Hurricane Katrina. Journal of Coastal Research, 23(4), 1002-1012.
- Couvillion, B. R., Barras, J. A., Steyer, G. D., Sleavin, W., Fischer, M., Beck, H., ... & Hartley, S. (2011). Land area change in coastal Louisiana from 1932 to 2010: US Geological Survey Scientific Investigations Map 3164. U.S. Geological Survey.
- Perry, J. E., Smith, J. M., & Colten, C. E. (2006). Approaching recovery: The politics of redevelopment after Hurricane Katrina. Journal of the American Planning Association, 72(2), 141-146.
- Feagin, R. A., Lozada-Bernard, S. M., Ravens, T. M., Möller, I., & Yeager, K. M. (2010). Does vegetation prevent wave erosion of salt marsh edges? Proceedings of the National Academy of Sciences, 107(15), 6691-6696.