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Ph.D. DISSERTATION DEFENSE

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Title: Optimized Nature-based Solutions for Resilient Coastal Flood Mitigation Under Climate Change

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ABSTRACT

Given the escalating impacts of climate change on coastal communities worldwide, there is a pressing need for enhancing coastal flood mitigation strategies in the face of increasing storm intensities and sea-level rise. Traditional approaches to coastal defense, typically reliant on hard infrastructure, have shown limitations in terms of environmental impact, sustainability, and adaptability to changing conditions. These limitations underscore the necessity for innovative solutions that integrate the resilience of natural systems with the protective certainty of engineered structures. However, a significant gap exists in quantitatively assessing the resilience of such hybrid systems during extreme events and in designing optimized characteristics considering the economic aspects of coastal defense projects. Addressing this critical need, the goal of this dissertation is to advance a quantitative understanding of the benefits of optimized hybrid vegetation-seawall systems for mitigating wave hazards and coastal flooding under a changing climate. The research integrates advanced numerical modeling with empirical analysis to explore the efficacy of hybrid green/gray coastal defense systems. Through the utilization of numerical models, this study calibrates and applies the model to simulate wave runup and overtopping against different beach profiles and storm conditions. The research methodology extends beyond traditional modeling, incorporating an innovative assessment of vegetation's drag coefficient calibration, the investigation of vegetation characteristics on seawall robustness and serviceability, and the application of AI-based models to predict performance in untested scenarios. This comprehensive approach facilitates a nuanced understanding of how hybrid coastal defenses respond to and mitigate flood risks under extreme weather events. The research will further investigate the benefits of hybrid vegetation-seawall solutions to mitigate wave hazards and coastal flooding under current and future mean sea levels and extreme waves. Findings from this dissertation illuminate the potential of vegetation in reducing wave runup, overtopping, and coastal flooding, thereby augmenting the flood resilience of seawalls in a changing climate.