Evaluation of Pavement Management Funding Requirements for Rural Road Network in Response to Climate Change-Induced Flooding Impacts: A Focus on Accessibility Loss Restoration

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Abstract

Climate change poses a challenge to the resilience of road networks. In recent years, the increasing frequency and intensity of extreme weather conditions have made road networks highly vulnerable to natural disasters. Moreover, the increasing unpredictability of climate-related events highlights the necessity of developing adaptive strategies to ensure their resilience. Road network plays a vital role in the socio-economic development of a country. The accessibility of rural areas is vital for the emergency response, and overall community well-being. Nevertheless, frequent flooding events, landslides, and the falling of large trees onto road surfaces due to adverse weather conditions can isolate entire communities, interrupt emergency response services, limit transportation of goods, and isolate individuals from healthcare, education, and economic opportunities. One of the critical aspects of road network resilience is the effective allocation of funds for pavement maintenance and rehabilitation. Several models and frameworks can be found in the literature for effective fund allocation in road asset management systems focusing on regular maintenance and rehabilitation works. Less priority has been given to fund allocation in terms of disaster-related rehabilitation. This raises the need to integrate disaster resilience into asset management systems as climate change continues to intensify extreme weather events, including heavy rainfall and storm surges. Resilient road networks can withstand and recover rapidly in the occurrence of such disruptive natural events. This study aims to evaluate the pavement management funding requirements for rural road networks in the context of climate change-induced flooding impacts, focusing on accessibility loss restoration. To achieve this, employed a comprehensive methodology that incorporates a damage estimation of roads following a flood event using depth damage functions to quantify the extent of damage incurred. To identify the inundated road sections utilized a GIS (Geographic Information System) approach, integrating flood hazard maps and exiting road network layers. Next, assessed the network conditions before and after a flood event using centrality measures. Network centrality, measured through indices such as betweenness and closeness centrality, offers insights into the criticality of individual road segments. It illuminates which roads play pivotal roles in maintaining connectivity, even under adverse conditions like flooding. Thereafter, prioritized the links by ranking them according to the potential impact on accessibility loss. Finally, an optimization model was employed to allocate the available budget for pavement management, ensuring that the most critical road links are restored first, thus maximizing the overall accessibility of the rural road network while taking into account the severity of the damage and the cost of repairs. This approach ensures that limited resources are used effectively, maximizing the restoration of accessibility across the rural road network.

This research aims to provide valuable insights for decision-makers and road authorities in rural areas facing climate change-induced flooding challenges to enhance the resilience of rural road networks. By adopting a systematic approach, that integrates damage estimation, network analysis, and budget optimization, this study offers a practical framework for addressing accessibility restoration needs in the face of climate change-induced flooding events. Ultimately,

this approach aims to make road networks better prepared to withstand and recover from flooding, contributing to more resilient and sustainable rural road networks.

Keywords: *Disaster Resilience, Climate Change, Rural Roads, Accessibility Restoration, Flooding Impact*

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