study the disruptive effects of earthquakes, traffic congestion, and flooding events on road networks (Loreti et al., 2022). Abdulla et al. (2020) presented a flood diffusion model to investigate the effects of flood diffusion on road network connectivity. By measuring the size of the giant components for each fraction of the removed nodes, they found that the connectivity of road networks was particularly vulnerable to flood propagation that started from nodes with high values of betweenness. Based on this study, Farahmand et al. (2020) proposed a probabilistic approach to examine the failure of road networks, which was assessed by calculating the giant component size of the network. The node removal process resulted in significant drops in network connectivity, as indicated by the size of the giant component. This indicates the existence of critical roads in the network. Dong et al. (2019) proposed a probabilistic link removal to mimic earthquake-induced failures and addressed the effects on the Portland Road network. They
consider critical infrastructures rather than giant components size based on global networks. Similarly, Loreti et al (2022) propose partitioning the Voronoi Cell-based road network of critical infrastructure and defining new measures that characterize the impact of the flood event. However, in urban environments, the coverage range and spatial distribution of infrastructures with different hierarchical levels is often not spatially uniform, which can be

Figure 1 Framework of Exploring the Impact of Road Disruption under Flood.

In Module 3, a new method for evaluating network robustness is presented, which is based on the component size list. The method involves removing nodes of high local importance at multiple levels, in order to investigate the impact on the speed of network collapse and dispersion.

3.1 Module 1: Data & context Layers

Challenges in integrating contextual information with road segments involve (i) no explicit local community representation as the boundary for road networks, as local node impacts on networks ofte

Figure 2 Framework of Module 1

3.2 Module 2: Modelling Layer

Challenges in extracting the local importance of road segments (i) Most existing methods have difficulties in capturing precise local information (Loreti et al., 2022); (ii) Although some methods attempt to capture local value, they focus on critical infrastructure rather than pedestrian travel behaviour (Dong et al., 2019). This approach would overlook some urban areas with fewer critical infrastructures, such as commercial areas.

The second module proposes a centrality calculation approach to integrate urban context information to extract the local importance of road segments in the network. The shortest path betweenness centrality measures a node's importance in a network based on its ability to connect different parts of the network (Freeman 1977). The betweenness $(\ )$ of a vertex v V is defined to be

$$(\ ) = \sum_{,} \frac{(\ ,\ |\ )}{(\ ,\ )} \tag{1}$$

, stands for the head and tail of the shortest path, denote by $(\ ,\ )$ the number of shortest $(\ ,\ )$-paths and let $(\ ,\ |\ )$

search algorithm (Goerdt, 1997) is utilised to calculate the connected components in the graph. Unlike previous approaches that rely only on the size of the giant component, our approach preserves the size of all components. As shown in Figure 4(c), this list of component sizes allows us to compare the dispersal of the network after disruption by component quantity, average value, and standard deviation of component size. In addition, the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) is used to evaluate the stability of the component size list. Our approach offl141.92 (Our)5( )nr.tr36(di(disper)(c)-7(Di] TJETfiAs)-121-8(e)4rst,)-2y,percugm

5. Conclusion

In conclusion, floods pose a serious threat to transport networks, and with climate change, population growth and rapid urbanisation, the frequency and severity of floods are likely to increase. To understand the effects of flooding on road systems, experts use a variety of methodologies, including percolation theory, to measure network robustness. However, considering the robustness of the network based solely on the giant connected component, it may not accurately represent the impact of flooding on local communities. This paper proposes a context-based boundary centrality approach for calculating the impact of local communities on each segment of the road network and a novel approach for evaluating network robustness based on the size of network components. The case study on the London transport network

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