# A Real-time Traffic Routing Framework for Flood Risk Management Using Live Urban Observation Data

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# Objective

- Based on the “Flood-PREPARED” project funded by NERC
- Improve the prediction and response to urban surface flooding from intense rainfall events
- Pervasive sensors for urban monitoring and traffic surveillance, coupled with modelling and big data analytics, provide new opportunities for managing the impacts of urban flooding through intelligent traffic management systems in real-time.
- Reduce the commuting risks for drivers by providing predictive information on road connectivity and congestion occurrence under urban flood events

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# Datasets

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- Traffic monitoring data: journey time from ANPR, average speed from SCOOT loops, vehicle count from CCTV cameras (https://newcastle.urbanobservatory.ac.uk/)
- Traffic speed and limitation from Traffic and Accident Data Unit (TADU, http://www.northeast-tadu.gov.uk/)
- Traffic statistical data from UK DfT and local city council
- Road network and topographical data (https://digimap.edina.ac.uk/)
- Flood inundation maps from modelling[1]
- Traffic flow predictions from a traffic vehicle prediction model[2]

[1] Xia X, Liang Q, Ming X, Hou J (2017) An efficient and stable hydrodynamic model with novel source term discretization schemes for overland flow and flood simulations. Water Resour Res 53:3730–3759. https://doi.org/10.1002/2016WR020055

[2] Peppa, M. V., Bell, D., Komar, T., and Xiao, W. (2018) Urban traffic flow analysis based on deep learning car detection from cctv image series, *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XLII-4, 499-506, doi: 10.5194/isprs-archives-XLII-4-499-2018

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# Flowchart

✓Four modules:

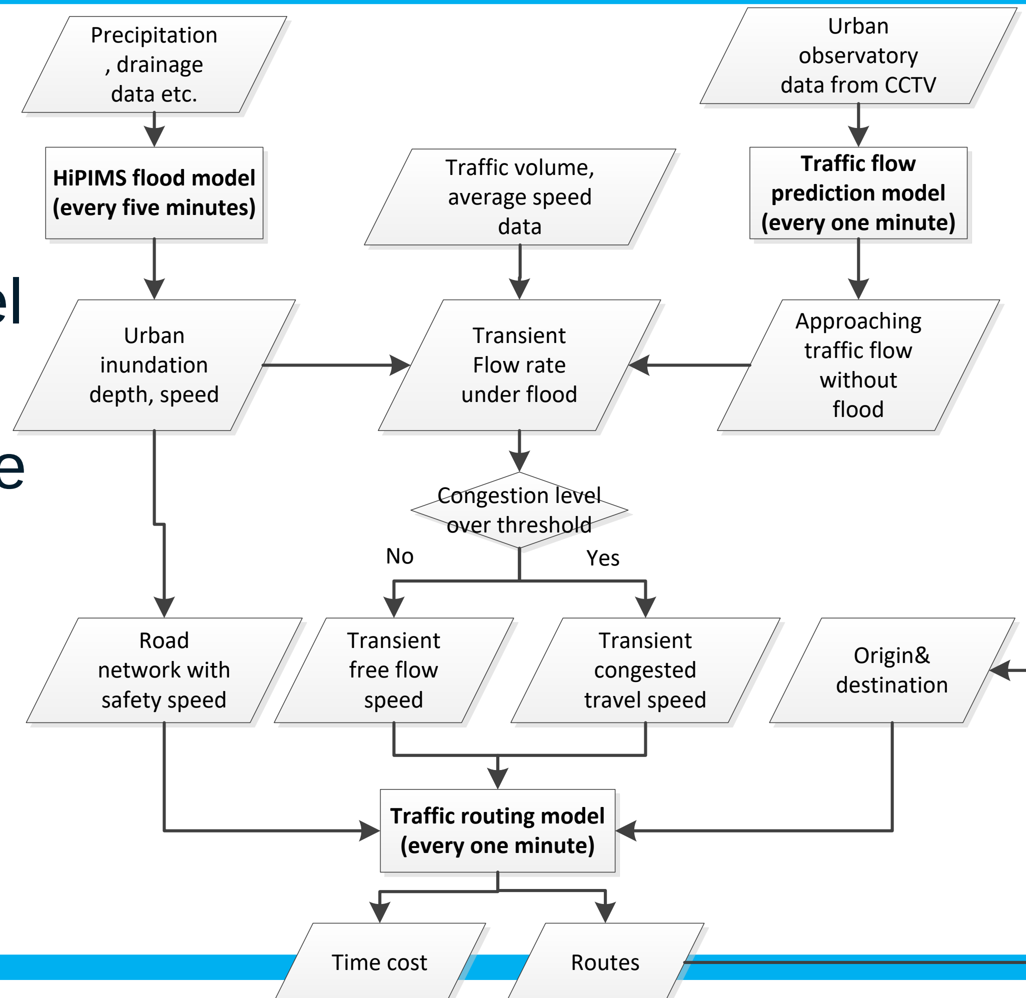
✓Flood model: HiPIMS[1]

✓Traffic flow prediction model [2]

✓Flood spatial impact module

✓Traffic routing module

✓Outcome: rerouting paths, and travel time

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# Method

- 1. Spatial topological analysis on flood modelling result in every 5 [illegible] minutes to get spatial index for flood patches over each roadlinks;
- 2. Road disruption and partially disrupted evaluation;
- 3. Using the relationship between flood depth and safety speed curves from [3] to adjust road free flow speed to safety speed;

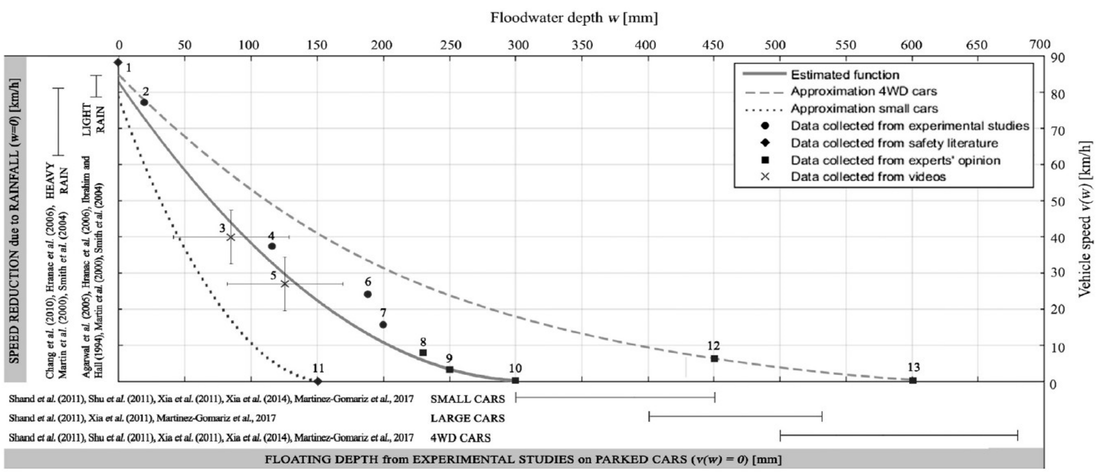


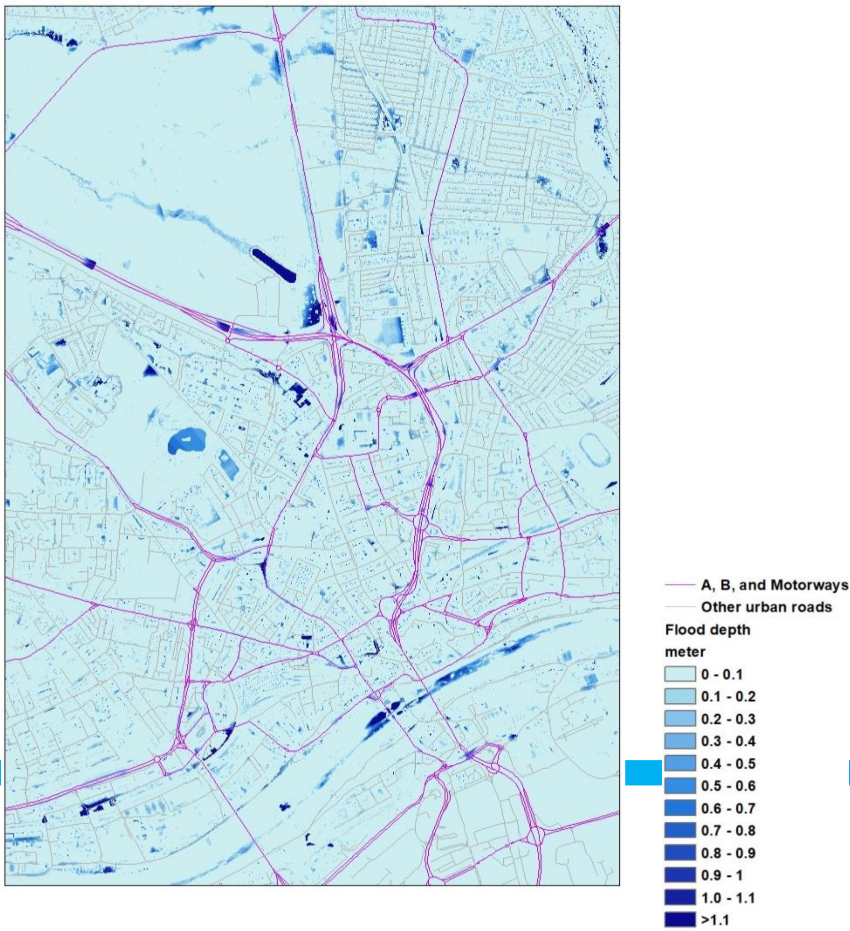

**Fig. 2.** The depth-disruption function that relates flood depth on a road with vehicle speed.

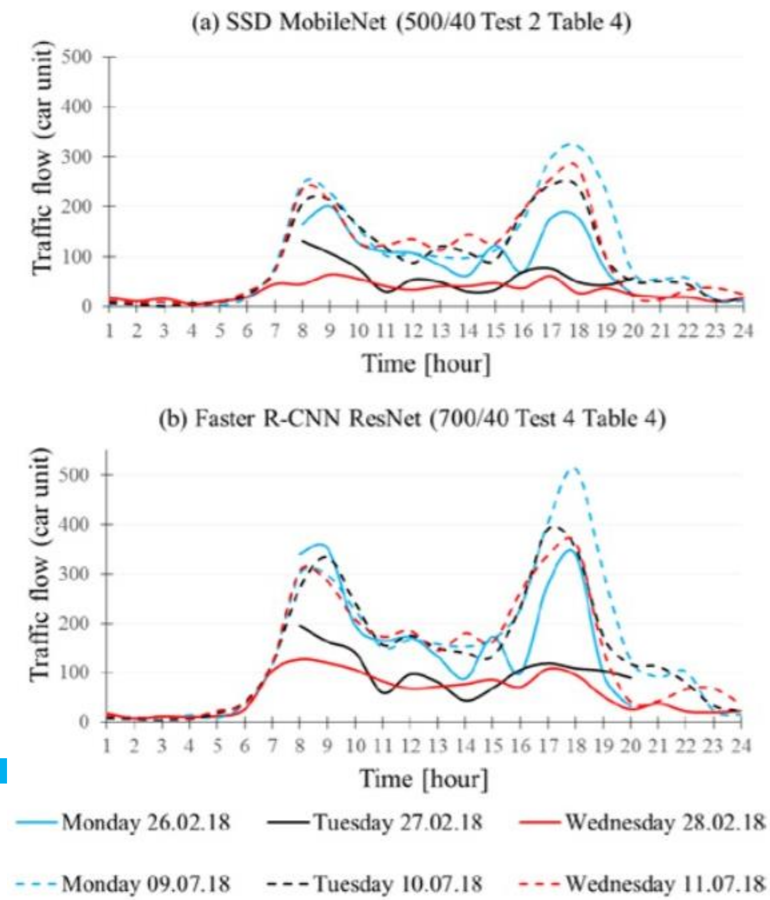
- 4. Predefined congestion levels with combination of weight matrix using traffic flow, average speed, and traffic volume according to [4]
- 5. Path routing with updated road network and roadlink properties


[3] Pregnolato M, Ford A, Wilkinson SM, Dawson RJ (2017) The impact of flooding on road transport: A depth-disruption function. Transp Res Part D Transp Environ 55:67–81. https://doi.org/10.1016/j.trd.2017.06.020
[4] Xu, X. , Gao, X. , Xu, Z. , Zhao, X. , & Zhou, H. . (2019). TCPModel: A Short-Term Traffic Congestion Prediction Model Based on Deep Learning. Artificial Intelligence. https://dio.org/10.1007/978-981-32-9298-7_6

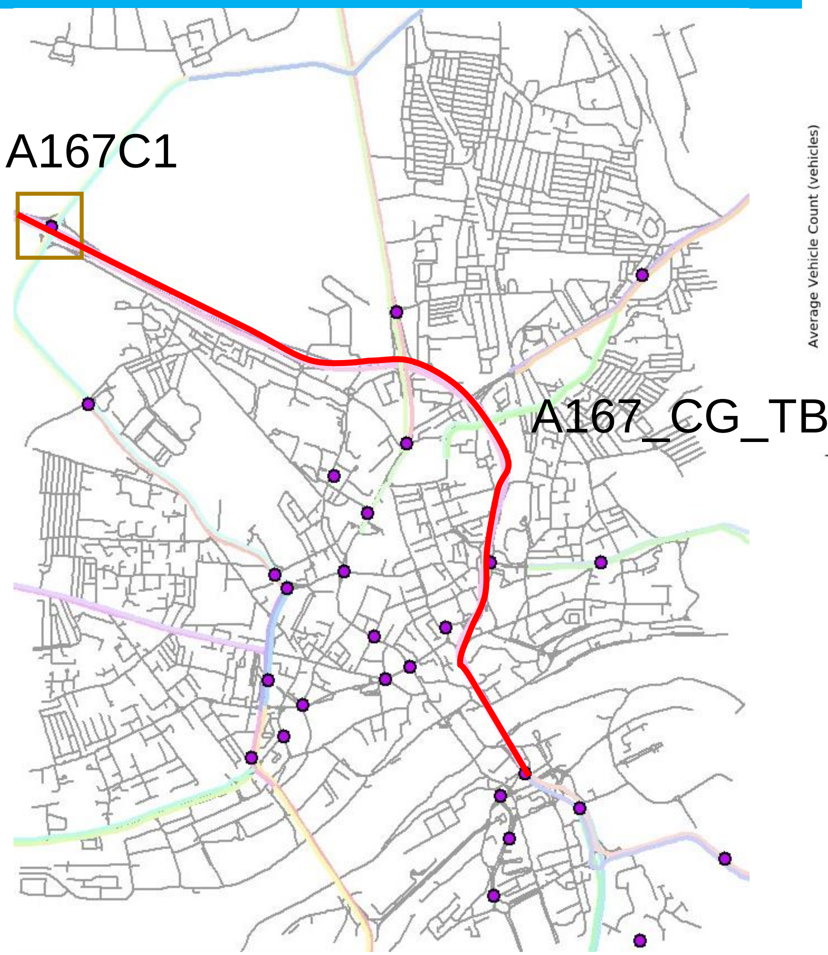
# Background results

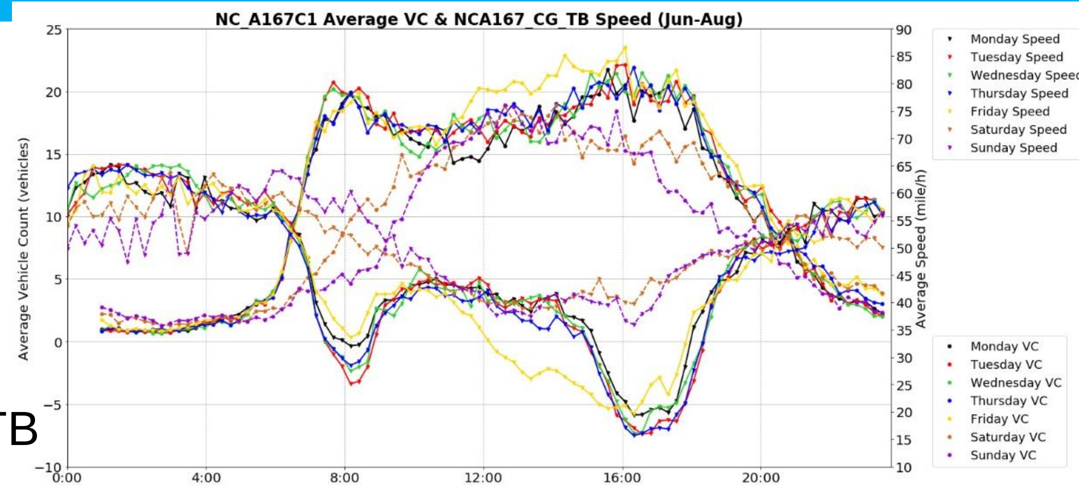
- Flood depth during the flood event (one in 100 years, similar with the actual flood on June, 2012)
- Traffic flow time series from prediction model [2]

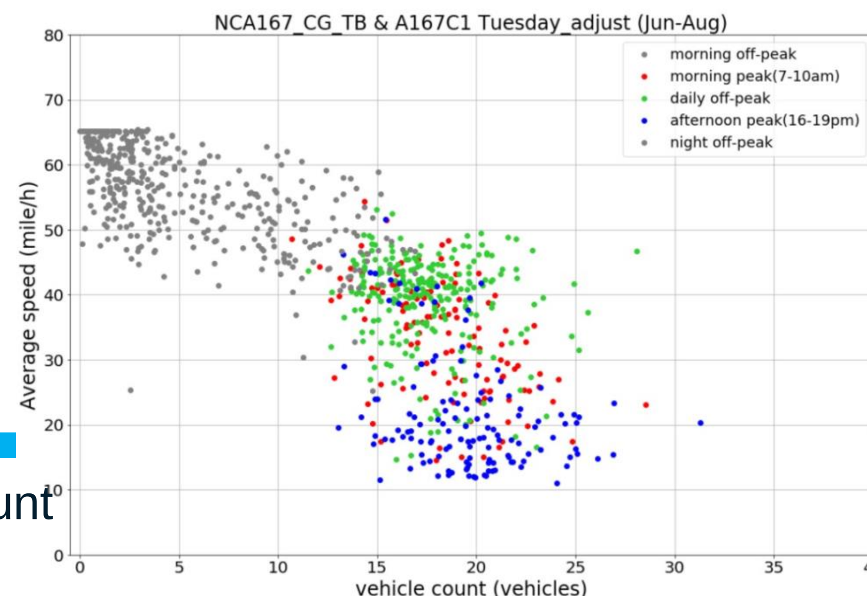


# Results




Traffic template between A167C1 vehicle count sensor and average speed of A167_CG_TB

# Results

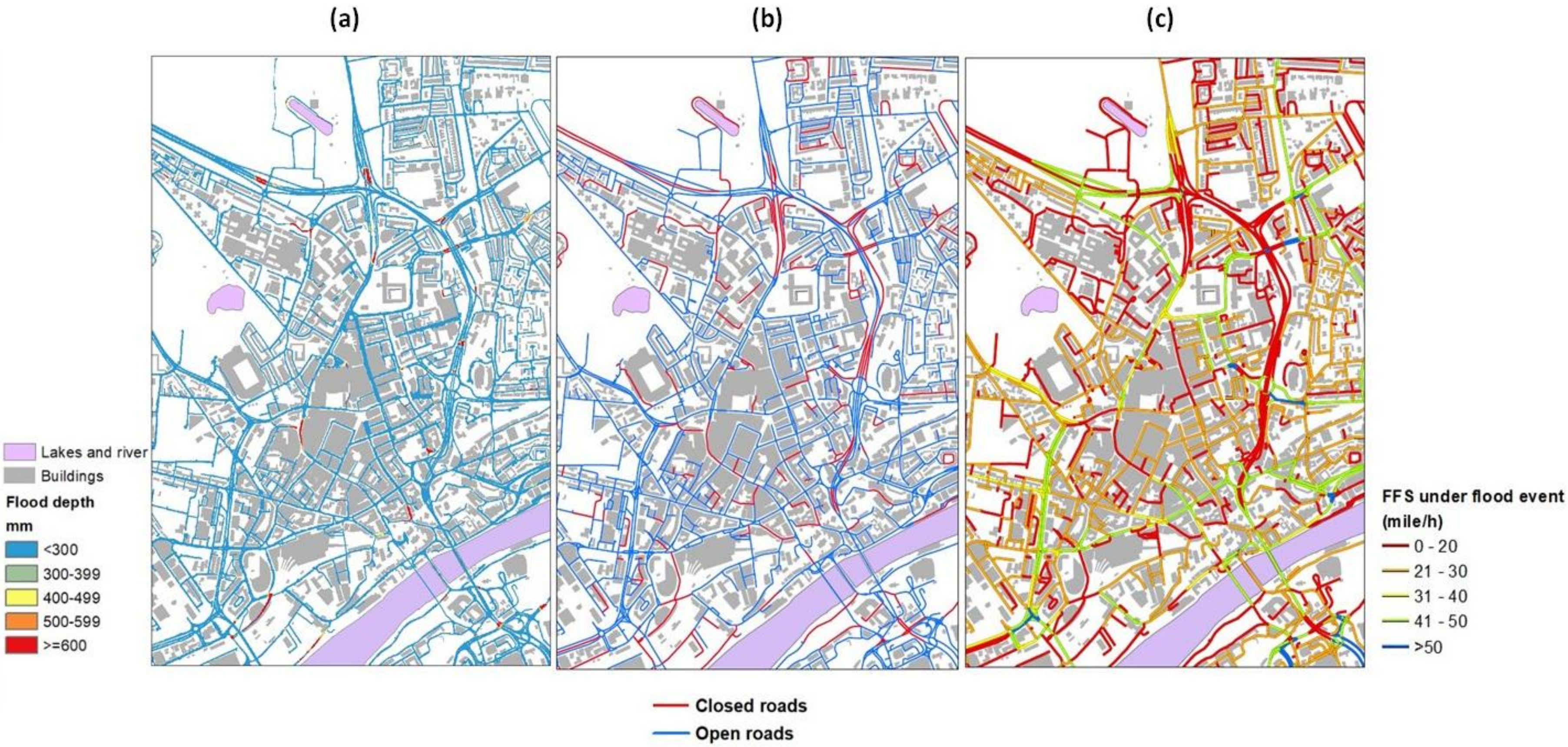



Figure1. (a) Flood water depth in millimeter on the road network; (b) closed roads and open roads after flood inundation as roads with flood depth higher than 300mm are regarded as closed roads under the flood event; (c) free flow speed (FFS) or safe speed in mile/h of each road under the flood event.

# Results

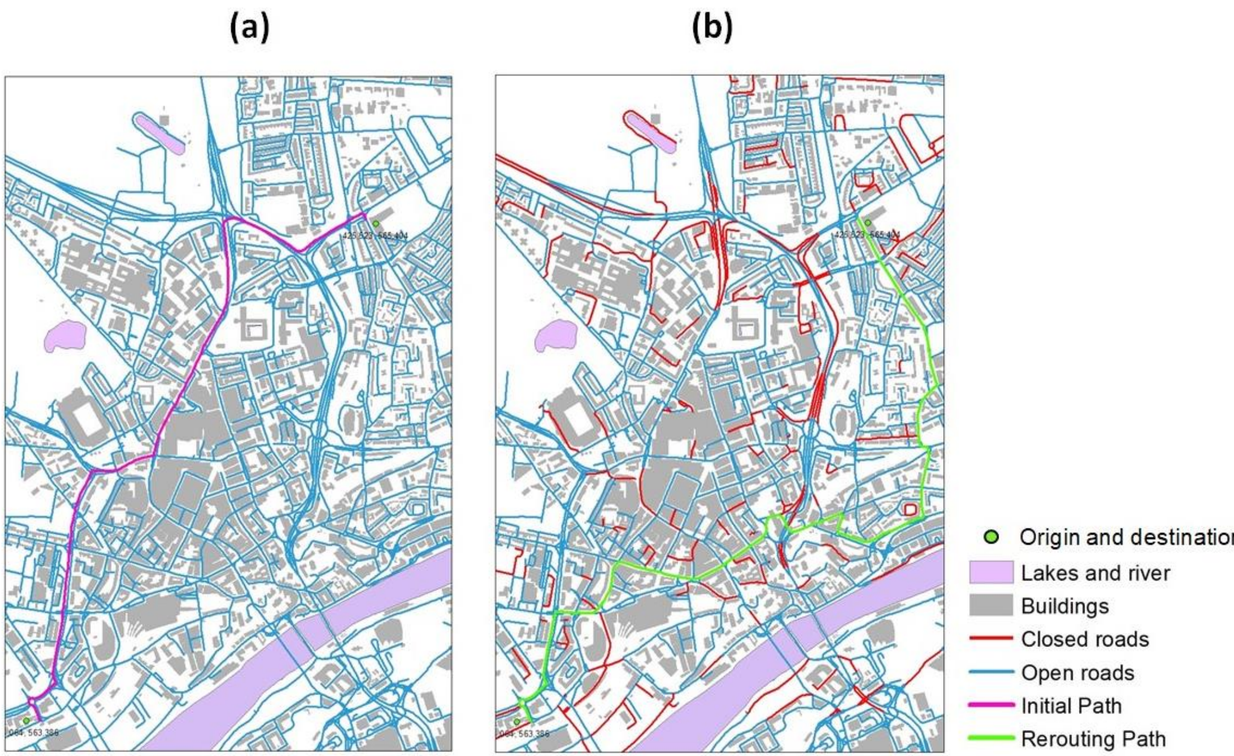



Figure2. (a) Initial path with the shortest time from origin to destination (south to north); (b) rerouting path avoiding all closed roads under the flood event.

| OD pairs | Original time cost (minutes) | Flooded time cost (minutes) |
|---|---|---|
| 1 | 3.4 | 5.98 |
| 2 | 4.85 | 5.13 |
| 3 | 2.47 | 4.67 |
| 4 | 2.68 | 4.2 |
| 5 | 3.79 | 5.37 |
| ….. | | |

Using 50 pairs of random origin-destinations, only 5 pairs will keep their original paths. The largest delay increase time cost to 90%