# An integrated scenario-based measuring for transportation resilience

## A case study of Pazhou, Guangzhou, Greater Bay Area

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# An integrated scenario-based measuring for transportation resilience

## A case study of Pazhou, Guangzhou, Greater Bay Area


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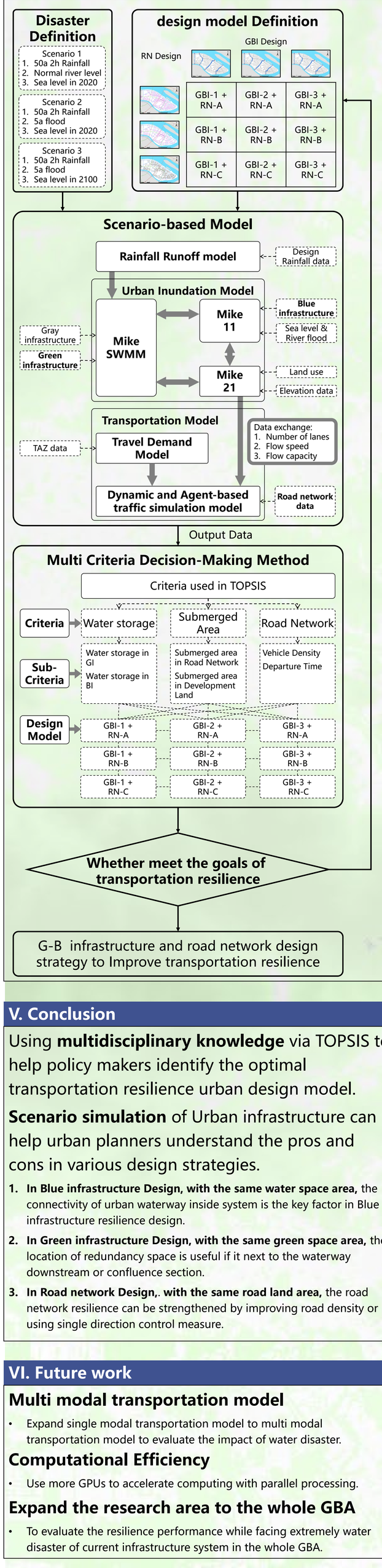
## I. Introduction

- The low-elevation landform make coastal area, especially **the Guangdong-Hong Kong-Macao Greater Bay Area (GBA),** more vulnerable to **heavy rainstorms** and **surge storm** in the future.
- **Resilience city** is an emergent concept applied in urban design model, and disaster management to deal with coastal hazards, such as **urban flooding**.
- **Infrastructure Planning and Design** served as a key component in improving **resilience performance** in GBA.
- Policy makers and urban planners need **quantitative method** to assess the **transportation resilience performance** and identify the optimal design model.

**Research question:**

**Which design strategy of Green-Blue infrastructure and road network can improve transportation resilience in GBA ?**

## II. Methodology




## III. Scenario-based Model Simulation

### • Disaster Definition

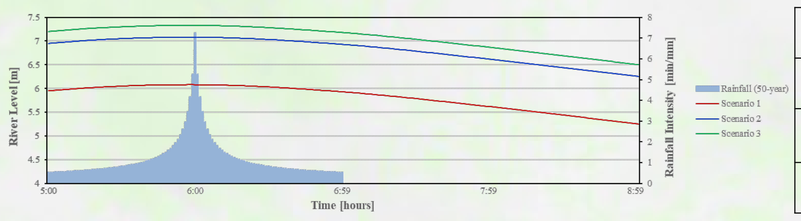



Figure 1 50-year rainfall and water level scenarios

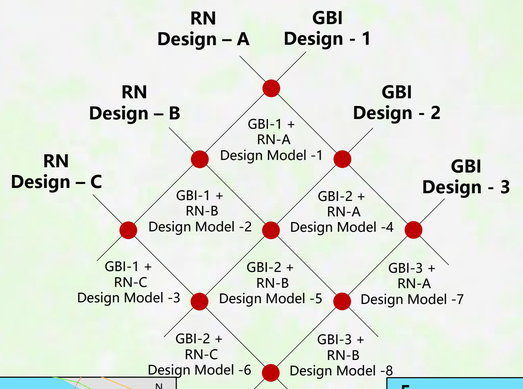
| Scenario | rainfall | River flood | Sea Level Rise |
|---|---|---|---|
| Scenario1 | 50-year 2h design rainfall | Normal river level | Sea level in 2020 |
| Scenario2 | 50-year 2h design rainfall | 5-year flood | Sea level in 2020 |
| Scenario3 | 50-year 2h design rainfall | 5-year flood | Sea level in 2100 |

Table 1 definition of three different scenarios

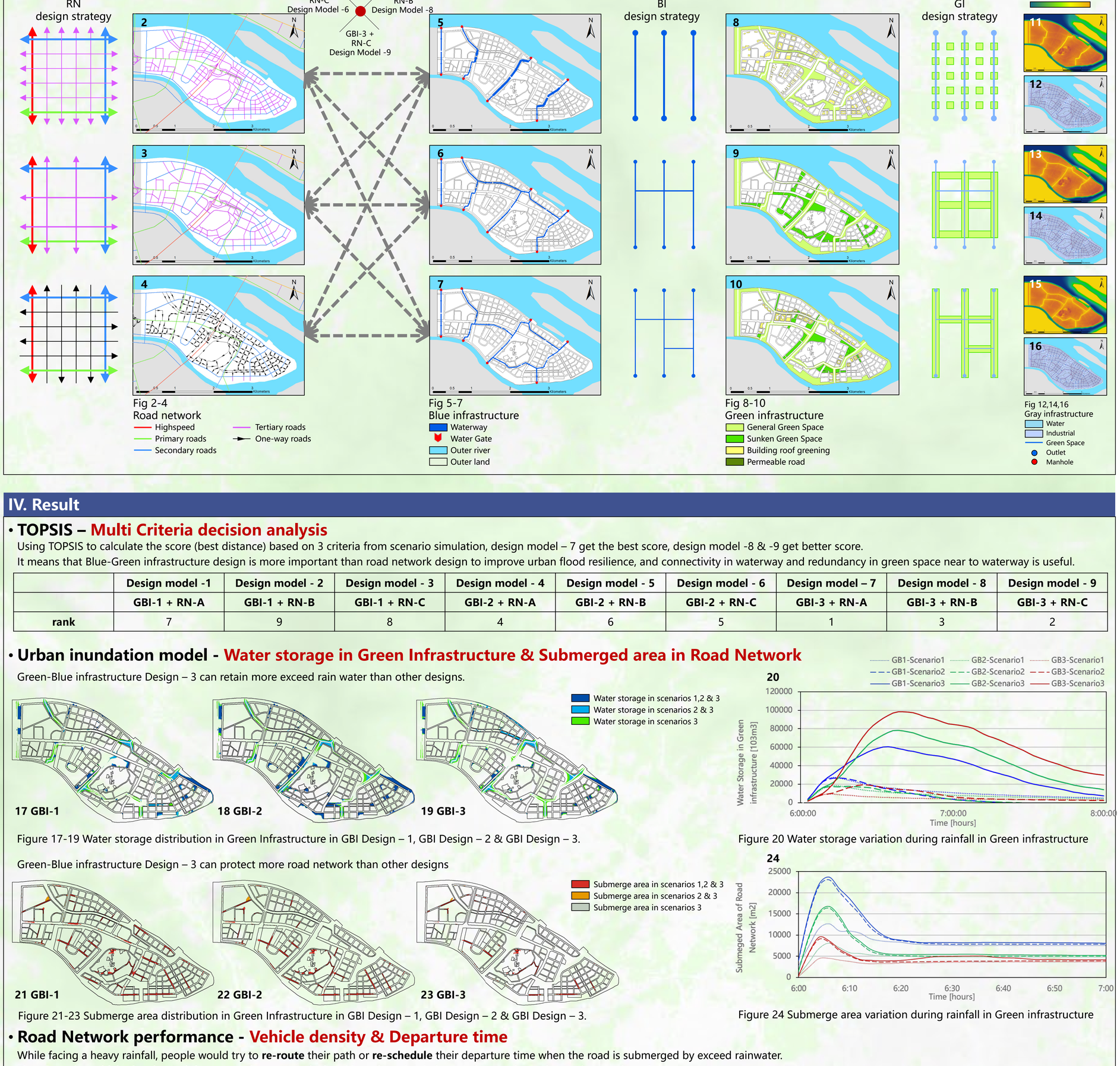
### • Design Model Definition – with the same water space area, green space area and road land area.

**9 different design models were generated by 3 Green-Blue Infrastructure (GBI) Designs & 3 Road Network (RN) Designs.**

| | |
|---|---|
| High density dual network | **Road Network Design – A** |
| Low density dual network | **Road Network Design – B** |
| High density single network | **Road Network Design - C** |




| | | | |
|---|---|---|---|
| **Green-Blue Infrastructure Design - 1** | The BI was designed as 3 individual parts, which connect 2 outlets with widest waterway, | LID projects was evenly distributed in area | The Gray infrastructure was designed to meet Specification for Urban Drainage Engineering Planning<br><br>The elevation was designed based on the green-blue infrastructure. |
| **Green-Blue Infrastructure Design - 2** | The BI was designed as a tree structure, which the main waterway is in the middle of island, | LID projects was designed as link to connect different waterways. | |
| **Green-Blue Infrastructure Design - 3** | The BI was designed as single loop structure, which narrow waterway to connect the 6 outlets | LID projects was designed in the buffer of waterway | |




## IV. Result

### • TOPSIS – Multi Criteria decision analysis

Using TOPSIS to calculate the score (best distance) based on 3 criteria from scenario simulation, design model – 7 get the best score, design model -8 & -9 get better score.

It means that Blue-Green infrastructure design is more important than road network design to improve urban flood resilience, and connectivity in waterway and redundancy in green space near to waterway is useful.

| | Design model -1 | Design model - 2 | Design model - 3 | Design model - 4 | Design model - 5 | Design model - 6 | Design model – 7 | Design model - 8 | Design model - 9 |
|---|---|---|---|---|---|---|---|---|---|
| | GBI-1 + RN-A | GBI-1 + RN-B | GBI-1 + RN-C | GBI-2 + RN-A | GBI-2 + RN-B | GBI-2 + RN-C | GBI-3 + RN-A | GBI-3 + RN-B | GBI-3 + RN-C |
| rank | 7 | 9 | 8 | 4 | 6 | 5 | 1 | 3 | 2 |

### • Urban inundation model - Water storage in Green Infrastructure & Submerged area in Road Network

Green-Blue infrastructure Design – 3 can retain more exceed rain water than other designs.




Figure 17-19 Water storage distribution in Green Infrastructure in GBI Design – 1, GBI Design – 2 & GBI Design – 3.




Figure 20 Water storage variation during rainfall in Green infrastructure

Green-Blue infrastructure Design – 3 can protect more road network than other designs




Figure 21-23 Submerge area distribution in Green Infrastructure in GBI Design – 1, GBI Design – 2 & GBI Design – 3.




Figure 24 Submerge area variation during rainfall in Green infrastructure

### • Road Network performance - Vehicle density & Departure time

While facing a heavy rainfall, people would try to **re-route** their path or **re-schedule** their departure time when the road is submerged by exceed rainwater.

Therefore, the **vehicle density** and **departure time** were calculated based on simulation result to evaluate the road network performance.

High density network and single direction network show similar better performance result than low density network.

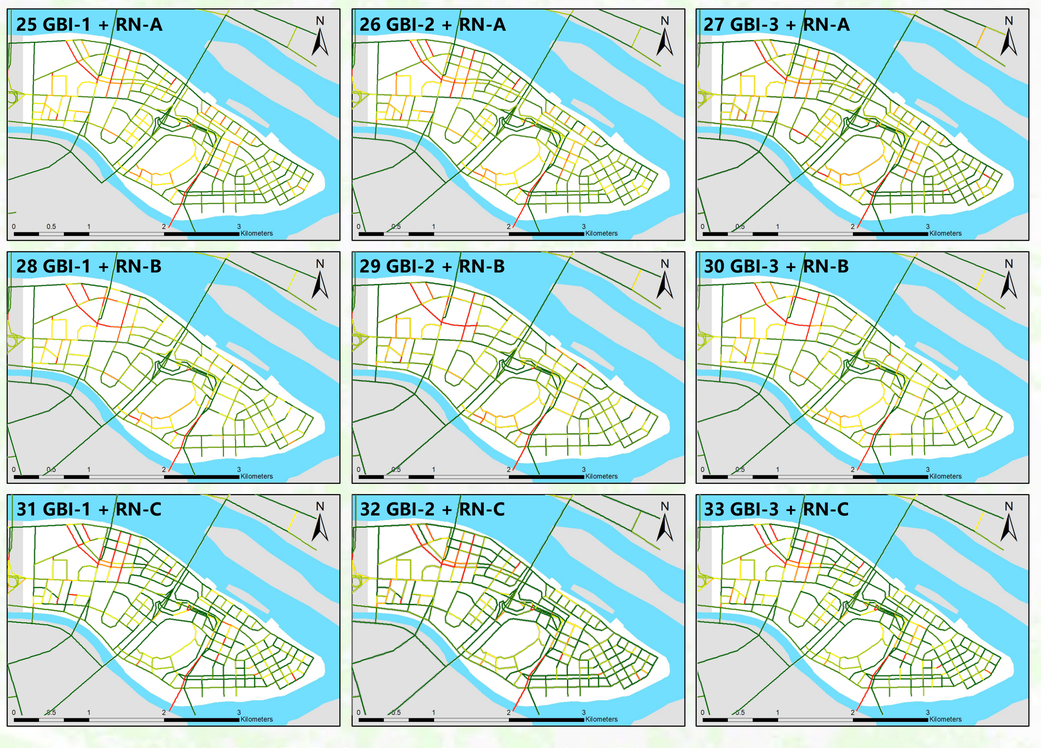



Figure 25-33 Vehicle densities distribution in 9 Design model3 in Scenario3. .

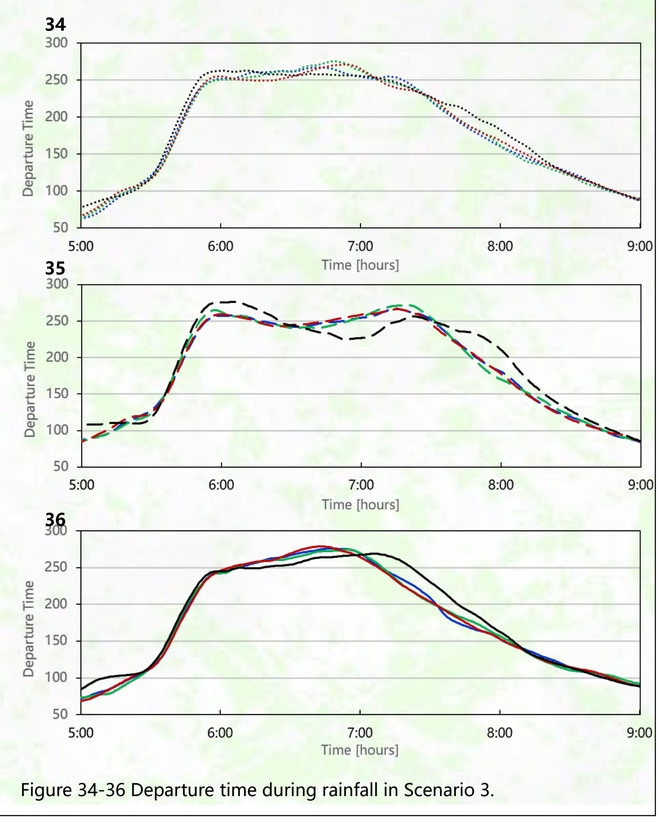



Figure 34-36 Departure time during rainfall in Scenario 3.

## V. Conclusion

Using **multidisciplinary knowledge** via TOPSIS to help policy makers identify the optimal transportation resilience urban design model.

**Scenario simulation** of Urban infrastructure can help urban planners understand the pros and cons in various design strategies.

1. **In Blue infrastructure Design, with the same water space area,** the connectivity of urban waterway inside system is the key factor in Blue infrastructure resilience design.
2. **In Green infrastructure Design, with the same green space area,** the location of redundancy space is useful if it next to the waterway downstream or confluence section.
3. **In Road network Design,. with the same road land area,** the road network resilience can be strengthened by improving road density or using single direction control measure.

## VI. Future work

### Multi modal transportation model

- Expand single modal transportation model to multi modal transportation model to evaluate the impact of water disaster.

### Computational Efficiency

- Use more GPUs to accelerate computing with parallel processing.

### Expand the research area to the whole GBA

- To evaluate the resilience performance while facing extremely water disaster of current infrastructure system in the whole GBA.

## VII. Acknowledgement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