FAIL-SAFE AND SAFE-TO-FAIL ADAPTATION: DECISION-MAKING FOR URBAN FLOODING UNDER CLIMATE CHANGE

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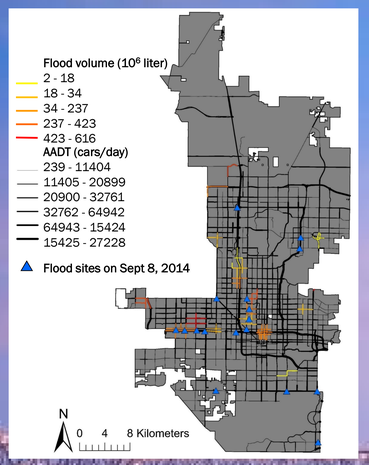
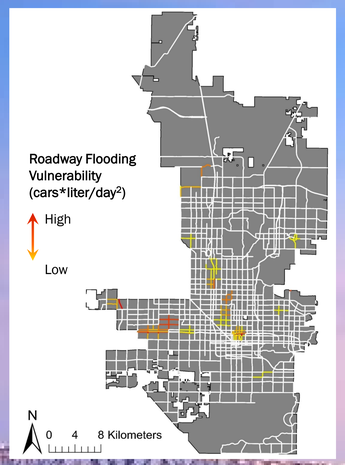
Background

As climate change affects precipitation patterns, urban infrastructure may become more vulnerable to flooding. Flooding mitigation strategies must be developed such that the failure of infrastructure does not compromise people, activities, or other infrastructures. “Safe-to-fail” is an emerging paradigm that broadly describes adaptation scenarios that allow infrastructure to fail but control or minimize the consequences of the failure. Traditionally, infrastructure is designed as “fail-safe” where they provide robust protection when the risks are accurately predicted within a designed safety factor. However, the risks and uncertainties faced by urban infrastructures are becoming so great due to climate change that the “fail-safe” paradigm should be questioned.

Q1. How might extreme weather due to climate change increase flooding of Phoenix roadways?

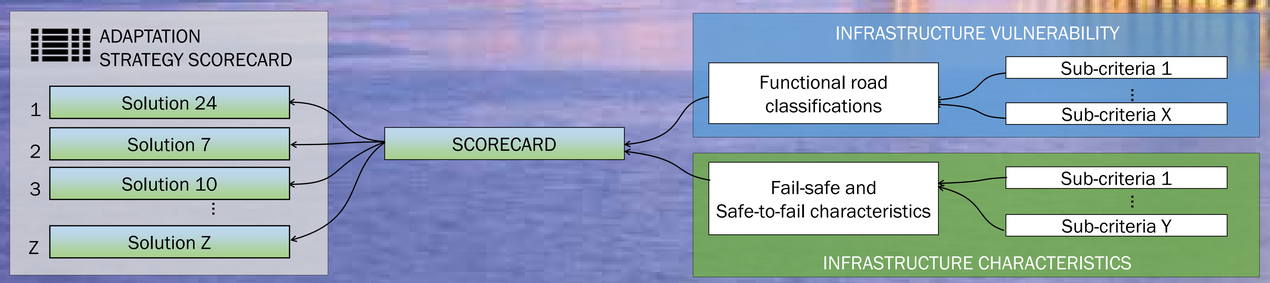




Flooding simulation
= ArcGIS Hydrology
+ EPA Stormwater Management Model (SWMM)

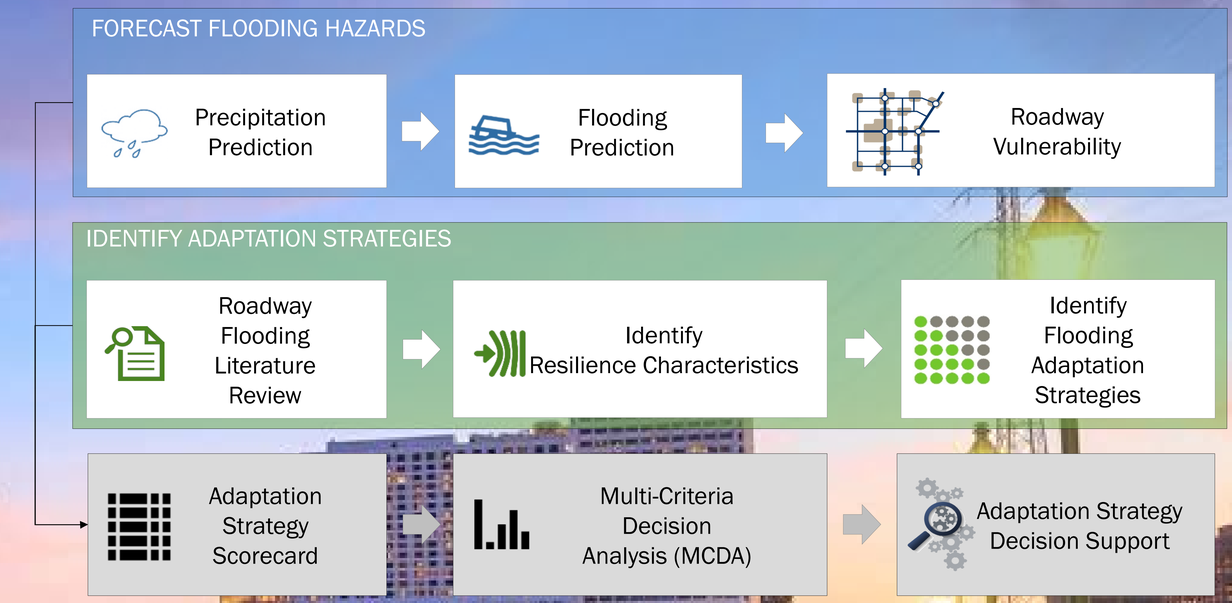
Roadway vulnerability
= Flooding volume x Annual average daily traffic

Q2. What “safe-to-fail” roadway solutions and adaptation strategies exist to mitigate climate change induced flooding?



Characteristic	All Criteria Equal	Fail-Safe Only	Safe-to-Fail Only	Ahern all	Ahern Strategies	Park Strategies	Park Processes
Armoring	√	√					
Strengthening	√	√					
Oversizing	√	√					
Isolation	√	√					
Fail-Silence	√	√					
Fail-Operation	√	√					
Multifunctionality / Flexibility	√		√	√	√	√	
Redundancy / Modularization	√		√	√	√		
(Bio and Social) Diversity	√		√	√	√	√	
Multi-Scale Networks / Connectivity	√		√	√	√	√	
Adaptability / Adaptive Capacity	√		√			√	√
Efficiency	√		√				
Renewability / Regrowth	√		√			√	
Sensing	√		√				√
Anticipation	√		√				√
Learning / Learning-by-doing	√		√	√	√		√
Transformability / Transformation	√		√			√	
Adaptive Design / Adaptive Planning	√		√	√		√	
Transdisciplinarity	√		√	√			

Q3. How should the City of Phoenix prioritize “safe-to-fail” strategies?



Rank	All Criteria Equal	Fail-Safe Only	Safe-to-Fail Only	Ahern All	Ahern Strategies	Park Strategies	Park Processes
1	Vegetated Bioretention Basin	Flood Storage	Vegetated Bioretention Basin	Activated Floodway	Activated Floodway	Discouraging Subsidence	RWIS
2	RWIS	Discouraging Subsidence	Activated Floodway	Vegetated Bioretention Basin	RWIS	Open Channel Conveyence	Activated Floodway
3	Activated Floodway	Multi-span Bridge	RWIS	RWIS	Vegetated Bioretention Basin	Vegetated Bioretention Basin	Vegetated Bioretention Basin
4	Flood Storage	Vegetated Bioretention Basin	Open Channel Conveyence	Flood Storage	Vegetation Management	Flood Storage	Vegetation Management
5	Discouraging Subsidence	RWIS	Discouraging Subsidence	Vegetation Management	Discouraging Subsidence	Activated Floodway	Relocate Service Buildings

Key Takeaways

- The roadway segment-specific vulnerabilities for the event of September 8, 2014 indicate several infrastructure design and management considerations. The most vulnerable road types are local arterials followed by interstate highways and local major collectors in Phoenix.
- The combination of literature review, flooding vulnerability assessment, and MCDA results show how switching between different “fail-safe” and “safe-to-fail” perspectives changes the recommended roadway flooding solutions.
- Different characteristics defining “fail-safe” and “safe-to-fail” that are context- and infrastructure- specific, and non-uniform weighting of MCDA help to capture resilience in the decision-making processes.

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