

# Predicting and Alleviating Road Flooding for Climate Mitigation

Amrita Gupta, Caleb Robinson, Bistra Dilkina



*Thanks to:*

Brendon Machado, Ricardo Macias, Keyan Halperin, and Lingzi Hong





# Flooding severely impacts human mobility and critical infrastructure

**Flooding caused by Hurricane Harvey in Houston, Texas**

# Flood hazards will increase over more than half of the globe, including Africa (IPCC 5th Assessment Report WG2 Ch3)

globally, there were  
524 floods from 1980-1989,  
865 from 1990-1999, and  
**1729 from 2000-2009** (UNISDR)

floods are responsible for  
**52% of deaths** and  
**44% of economic damages**  
from natural disasters in 2017 (CRED)

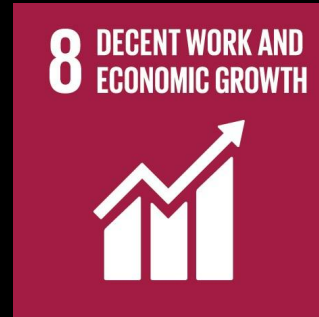


Flooding and mudslides in Africa caused over **1,240 deaths this August**

<https://qz.com/1068790/floods-in-africa-in-august-killed-25-times-more-people-than-hurricane-harvey-did/>

# How can we help?

Determine the most critical roads to upgrade to improve flood resilience



1. Estimate flooding effects on road network
2. Compute resulting impact on mobility
3. Recommend road fortifications that most effectively prevent loss of mobility

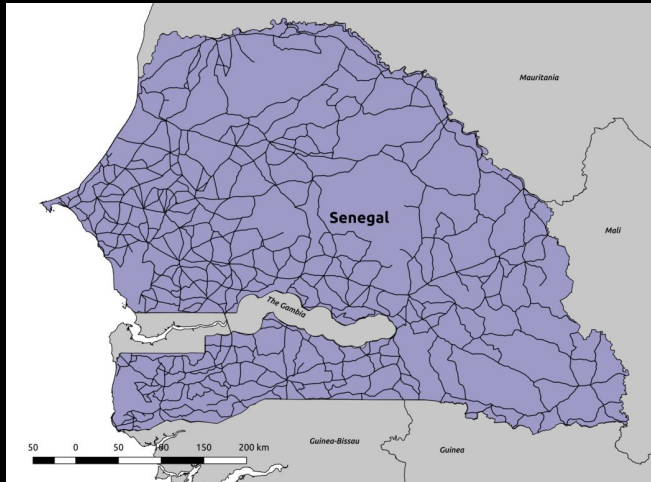


South Africa: Rehabilitation of Mpumalanga road

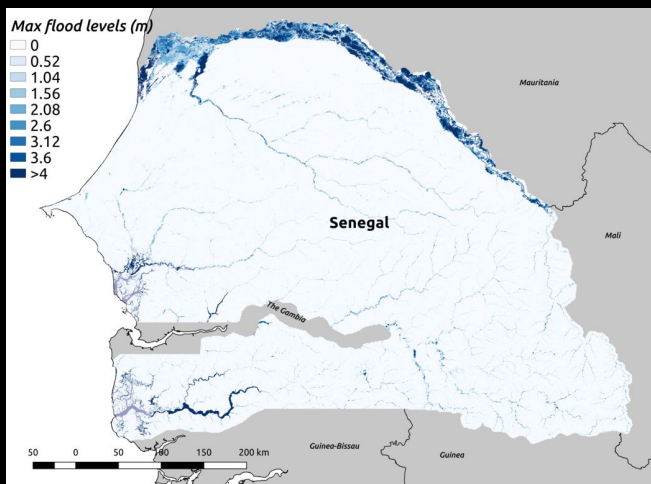
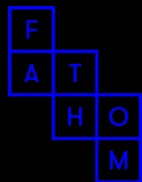
<https://constructionreviewonline.com/2015/02/south-africa-rehabilitation-mpumalanga-road-end-next-year/>

# How is the Road Network Affected by Floods?

GIS data on Senegal highway network (OSM)



Estimated flood maps for different flood return periods (Fathom)

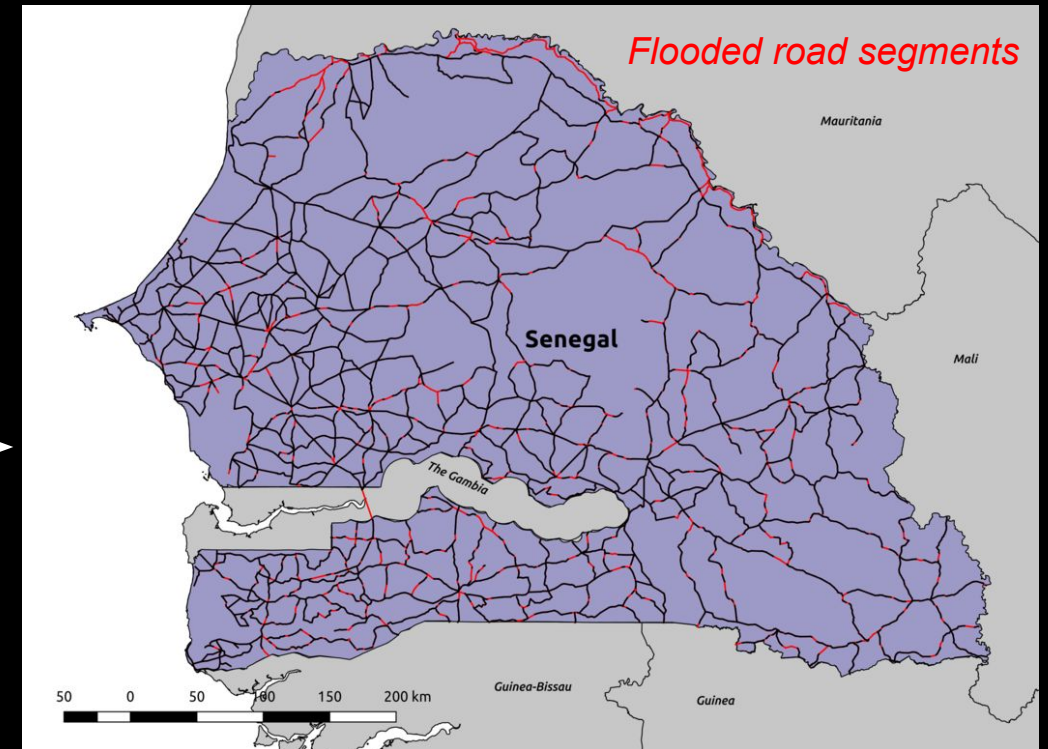


apply flood depth threshold

compute intersections



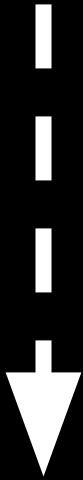
designate segment as flooded



Road segments estimated to be impassable during a flooding event of the given return period

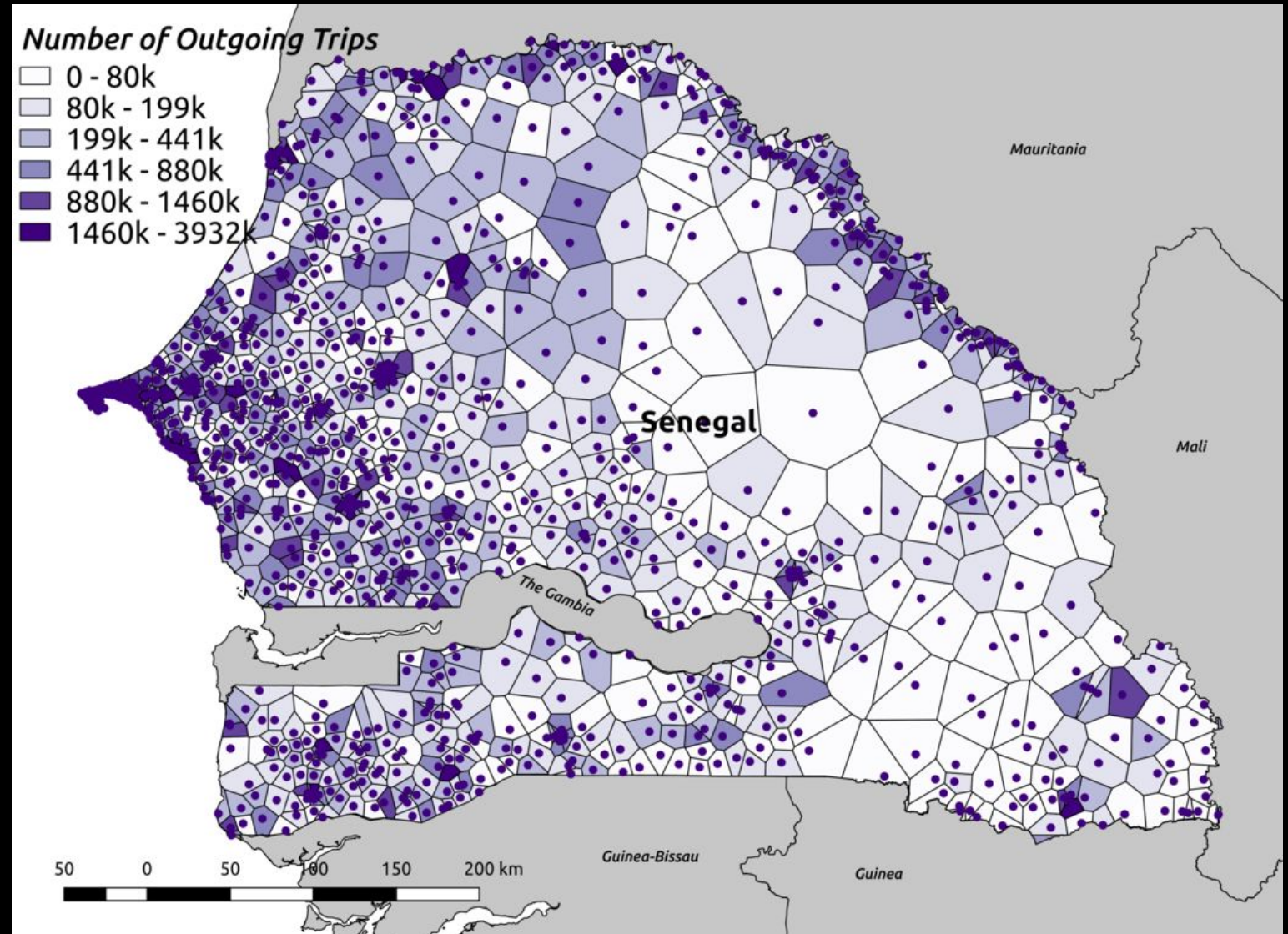
# How is Mobility Affected by Flooded Roads?

Using data from **Orange** we estimate the trips people are taking over the road network



Using trips people are taking we estimate how they are disrupted by **flooding**

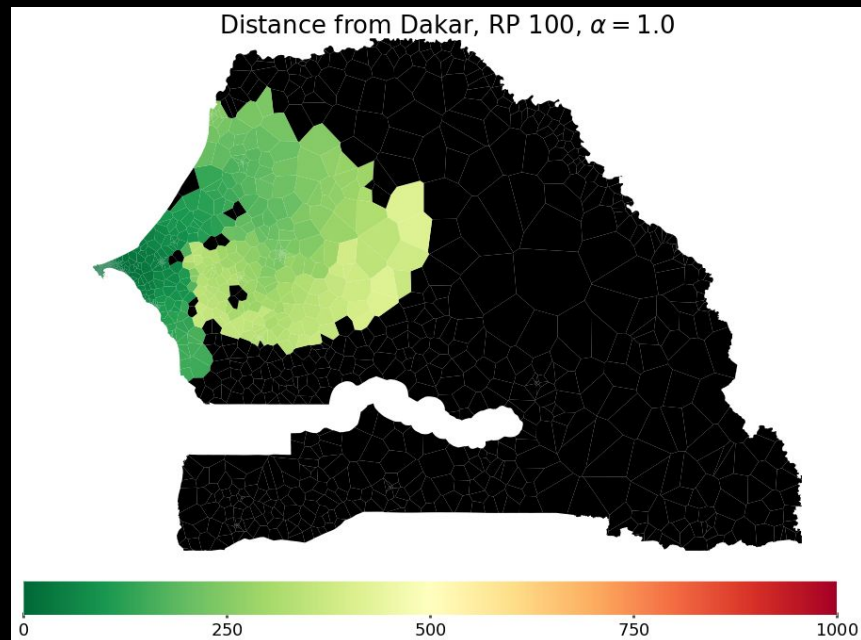
- **Shortest path distance** from origin to destination along the road network
- Number of **infeasible trips**



*Estimated number of outgoing trips for zones defined by Orange cell tower locations*

# Which Road Upgrades Would Have the Largest Impact on Mobility?

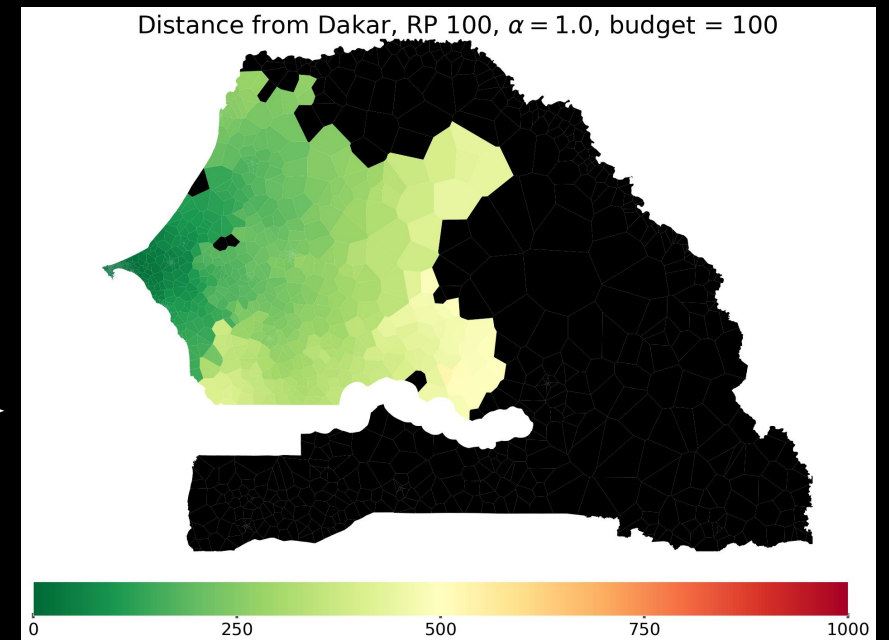
Given a limited budget, which set of roads should we fortify to maximize accessibility under a certain flooding scenario? **A hard combinatorial optimization problem!**



Distance from Dakar before Improvements  
(black areas are unreachable)

budget for  
100km  
upgrade

Approximation  
Algorithm for  
Optimization



Distance from Dakar after Recommended Improvements

## No Upgrades

## Fortify 100km

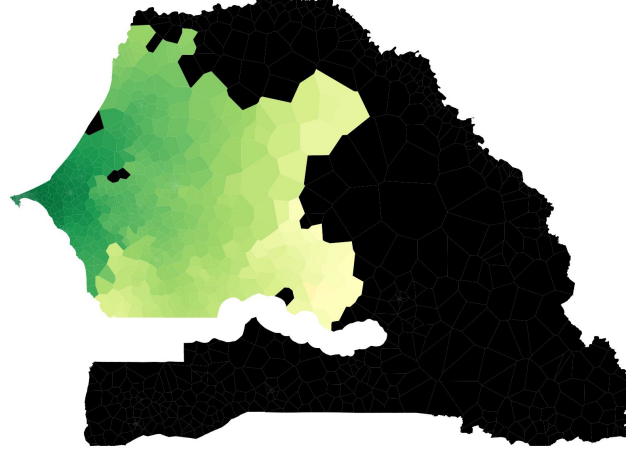
## Fortify 300km

**Dakar**  
(high population)

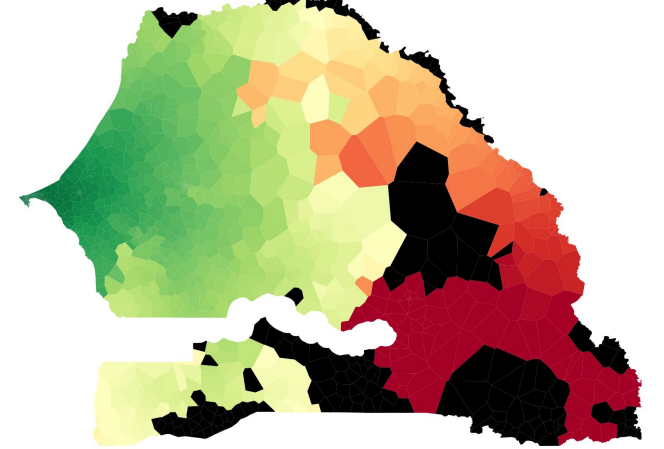
Distance from Dakar, RP 100,  $\alpha = 1.0$



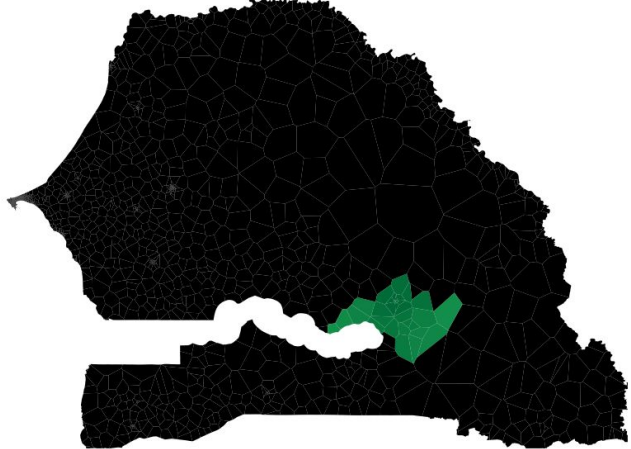
Distance from Dakar, RP 100,  $\alpha = 1.0$ , budget = 100



Distance from Dakar, RP 100,  $\alpha = 1.0$ , budget = 300



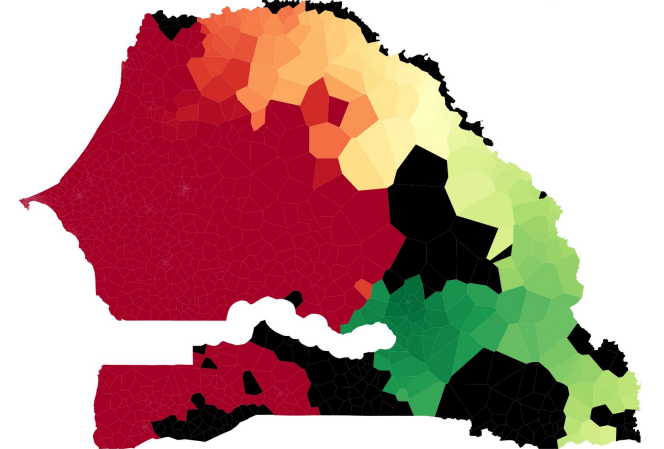
Distance from Tambacounda, RP 100,  $\alpha = 1.0$



Distance from Tambacounda, RP 100,  $\alpha = 1.0$ , budget = 100



Distance from Tambacounda, RP 100,  $\alpha = 1.0$ , budget = 300



*As more budget is used to minimize infeasible trips, more areas become reachable along the road network*





# ***Predicting and Alleviating Road Flooding for Climate Mitigation***

- Thank you **Data for Climate Action Challenge**
- Thank you **Orange and Sonatel** for access to the mobility data
- Thank you **Fathom.Global** for access to the flooding data
- Thank you **Data Science for Social Good Summer students** for the hard work and brainstorming



Amrita Gupta  
agupta375@gatech.edu



Caleb Robinson  
calebrob.com  
dcrobins@gatech.edu



Bistra Dilkina  
www.cc.gatech.edu/~bdilkina  
bdilkina@cc.gatech.edu

**Thanks!**

