NWIRP Research Study of Hurricane Maria (Puerto Rico)

Infrastructure Systems Supporting Critical Buildings and Emergency Communications

Project Leader: Ken Harrison

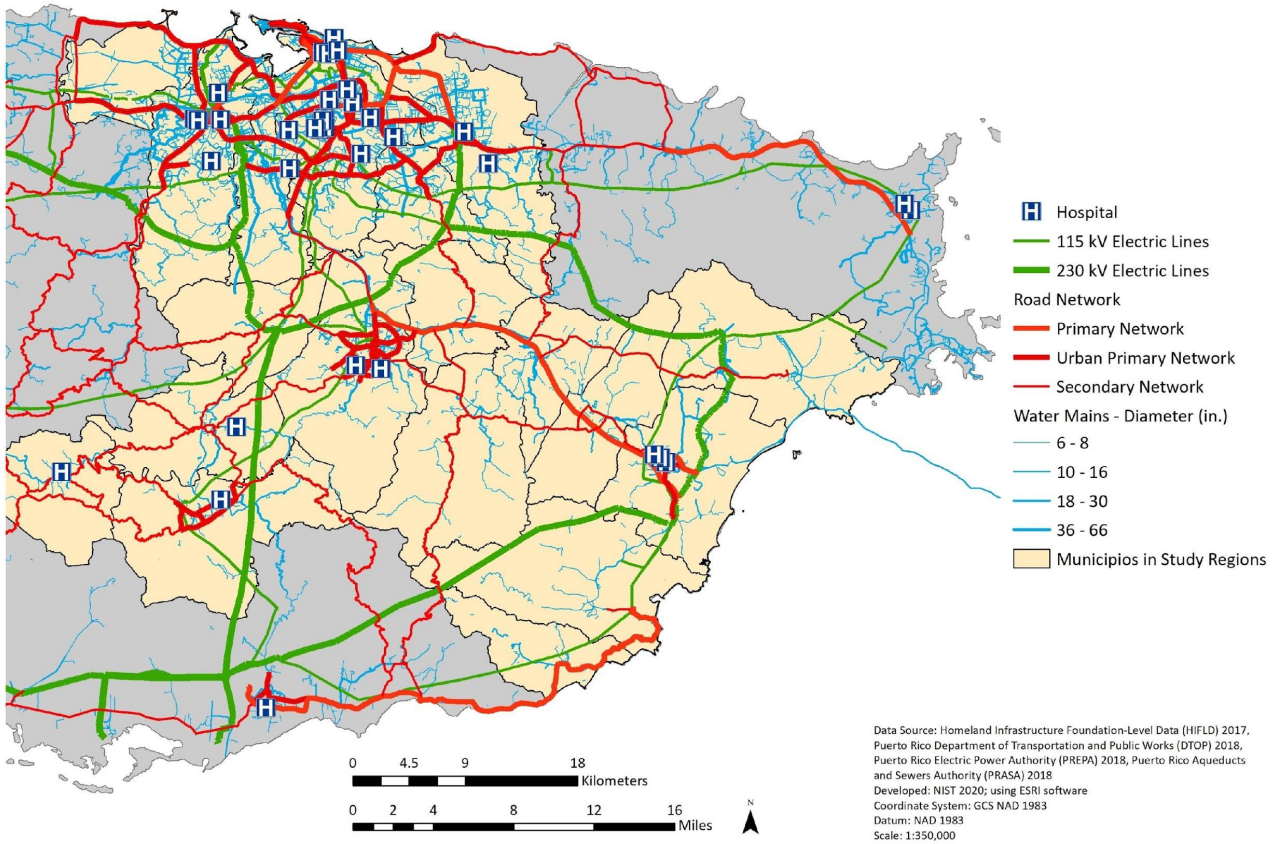
Background and Motivation: Resilience

"The term 'resilience' means the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions."

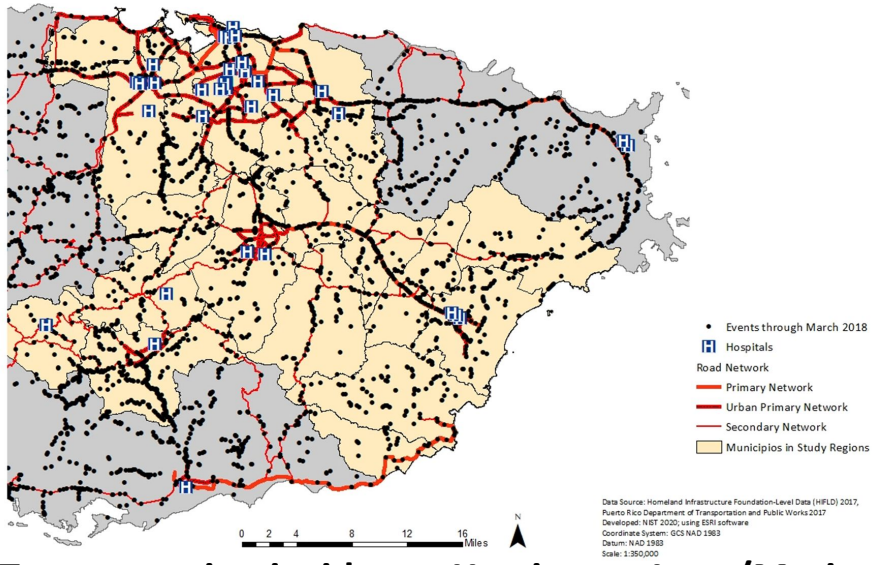
-Presidential Policy Directive/PPD-21, 2013

Background and Motivation: Importance of Dependencies on the Support of Critical Buildings

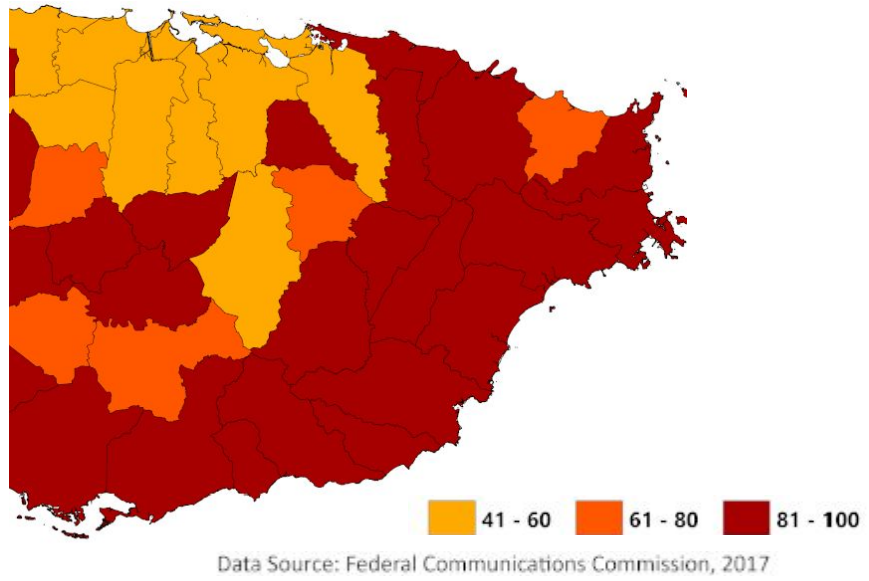
- To <u>minimize</u> the ***loss*** and ***time to recovery*** of infrastructure support of critical buildings, it is important to understand ***dependencies*** between infrastructure systems



<u>**Hospitals and high-capacity water, power, and transportation links**</u>



<u>**Transportation incidents: Hurricanes Irma/Maria**</u>



<u>**Cell Sites Out-of-Service 10/21/17, by Municipio (%)**</u>

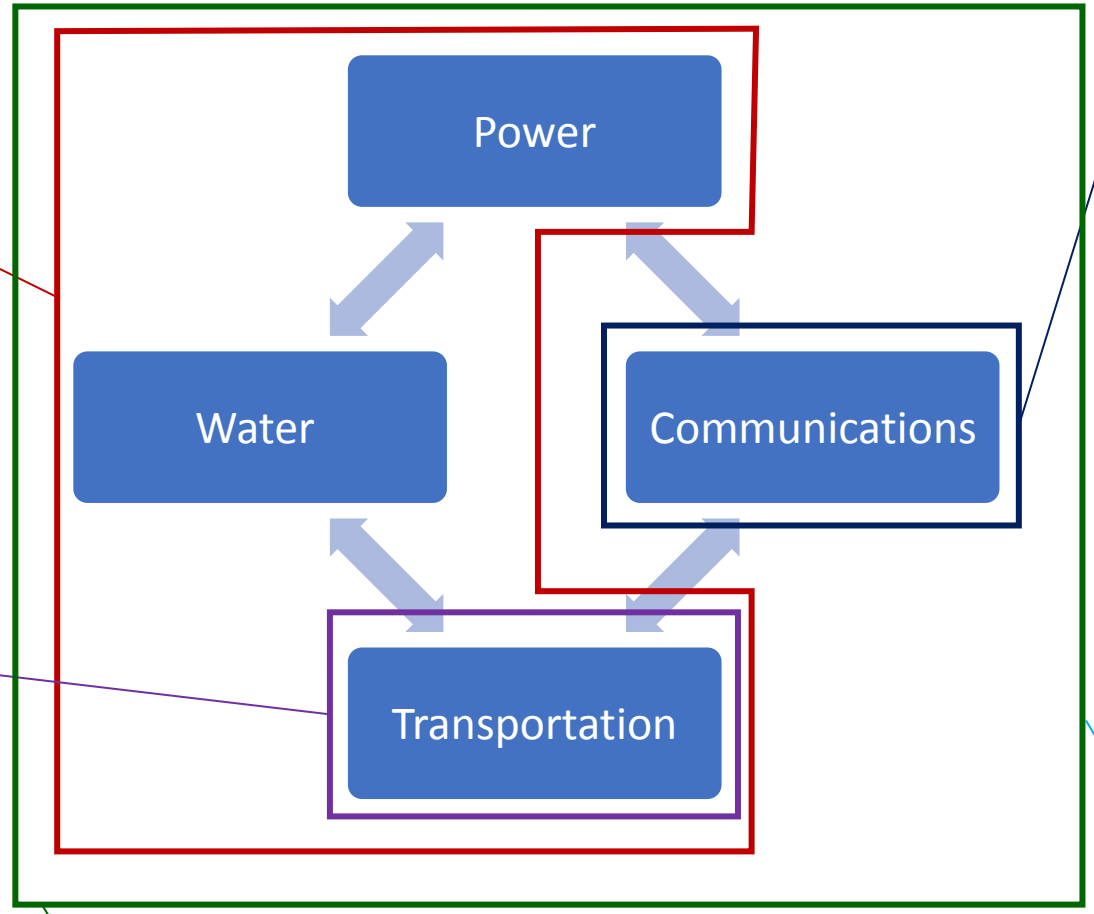
Project Plan: Five Project Components

Dependencies

Objective: Evaluate dependencies in power, water, and transportation infrastructure impacts, recovery, and decision-making

Transportation Incident Analysis

Objective: Mine the PR DTOP Transportation Incident Database to answer HM program questions



Vegetation Remote-Sensing (new project component)

Objective: Apply remote-sensing data to relate vegetation condition and infrastructure resilience

Wireless Communications

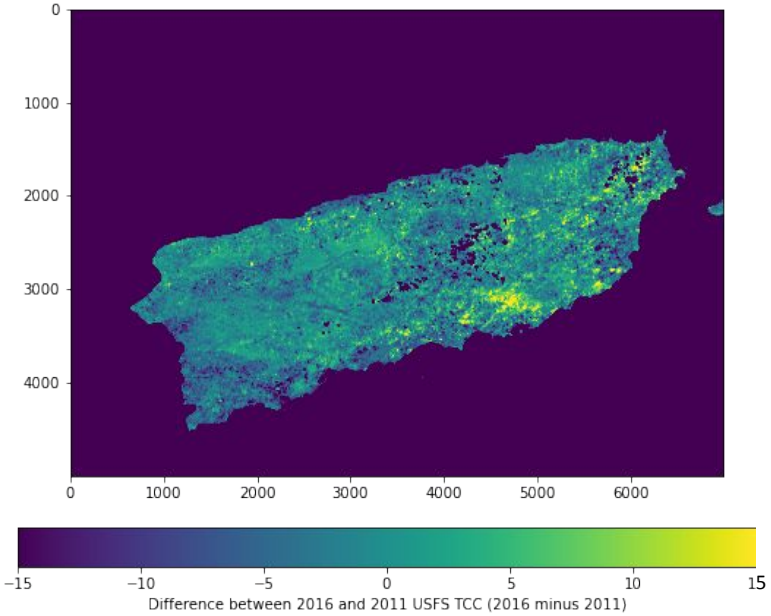
Objective: Investigate causes of the loss of functionality and extended-duration outage of the wireless communication system in Puerto Rico following Hurricane Maria

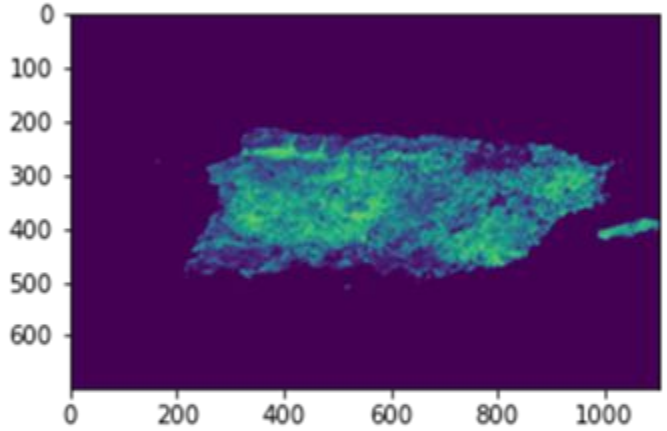
Integrative Study

Objective: In a case study for a community in Puerto Rico, evaluate the potential for model support of resilience decision-making

New Project Component: Vegetation Remote Sensing

- Motivation
  - *Transportation:* incident analysis: at least 1/3 of road incidents from debris
  - *Power:* DOE findings & recommendations pertaining to vegetation[1]:
    - *Transmission:* trouble accessing transmission corridors
    - *Distribution:* vegetation management would have been "…decisive factor limiting the extent of damage…"
- Satellite remote-sensing data: tree canopy cover (TCC)
  - Landsat-based from USFS (30 m maps available for 2011 & 2016)
  - MODIS-based (250 m; annual maps for 2000-2020)



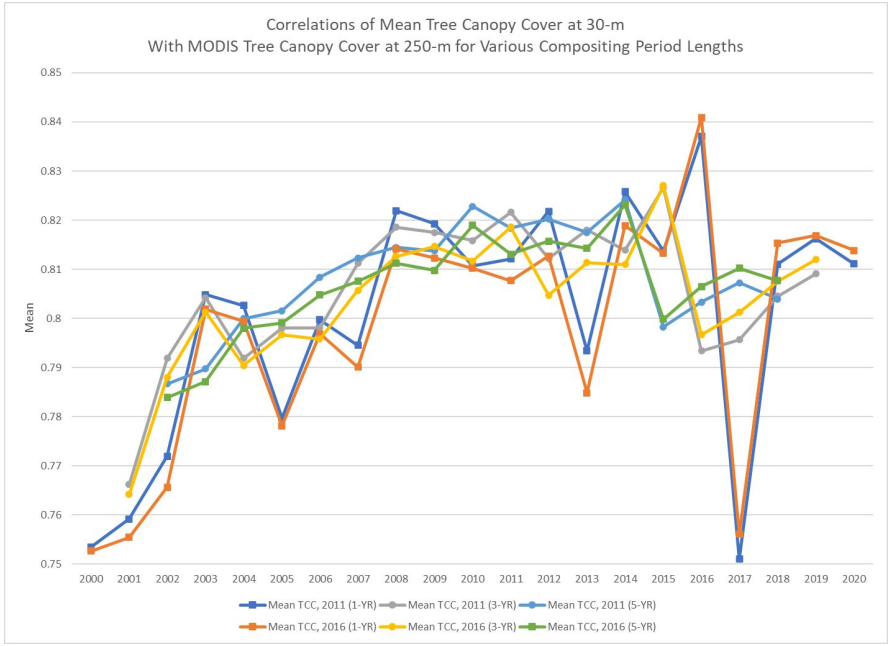


Example of greater resolution of Landsat 30 m (top; a map of change in TCC from 2011 to 2016) and MODIS 250 m TCC for one year (2017)

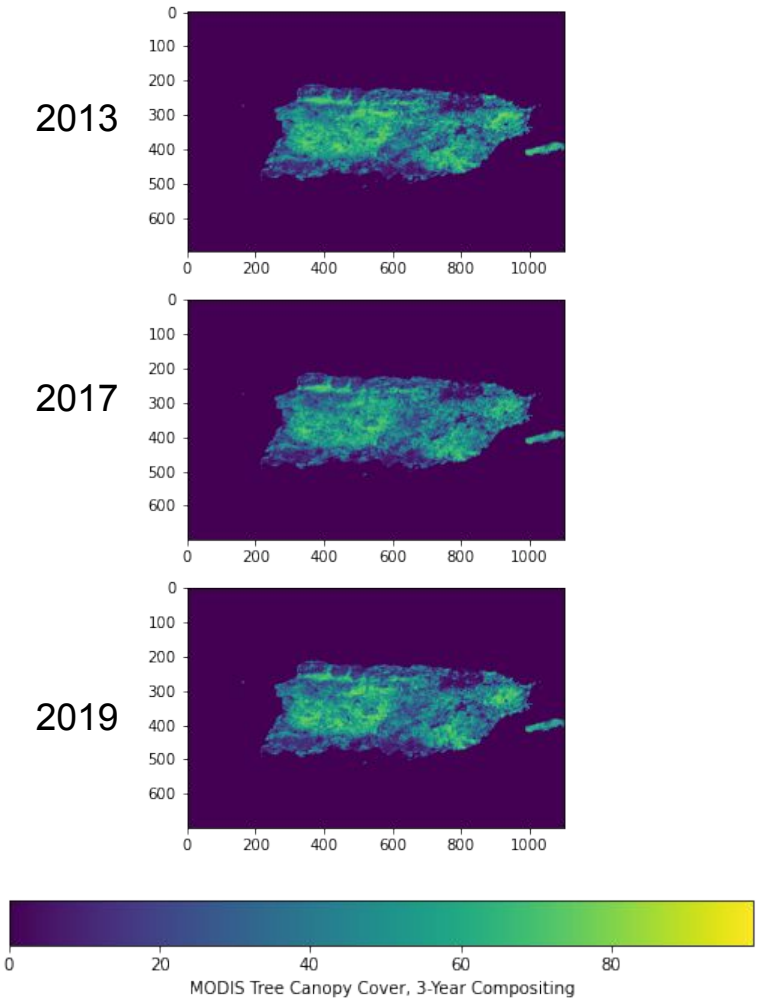
[1] Energy Resilience Solutions for the Puerto Rico Grid (2018) (U.S. Department of Energy (DOE)).

Recent Progress: Vegetation Remote-Sensing

- New data product: 3-yr, 5-yr composited TCC from MODIS (250 m; right)
  - Value added: temporal compositing needed due to data quality issues as indicated by per-pixel MODIS quality flags
  - Compositing: on a per-pixel basis, select the observation flagged with the highest available quality.



Correlation of *Landsat 30 m* with native *MODIS 250 m* called attention to potential quality issues, motivating image compositing.



Recent Progress: Wireless Communications

- Identified additional imagery sources
- Assessed available aerial imagery for efficacy at capturing tower damage
- Created geoprocessing model to extract images of cell towers from high-resolution post-storm imagery
- Used model to extract images for four categories of towers from FCC dataset (738 towers):
  - Free-standing or guyed structure
  - Lattice tower
  - Mast
  - Monopole
- Analyzed extracted images and identified additional collapsed and damaged towers

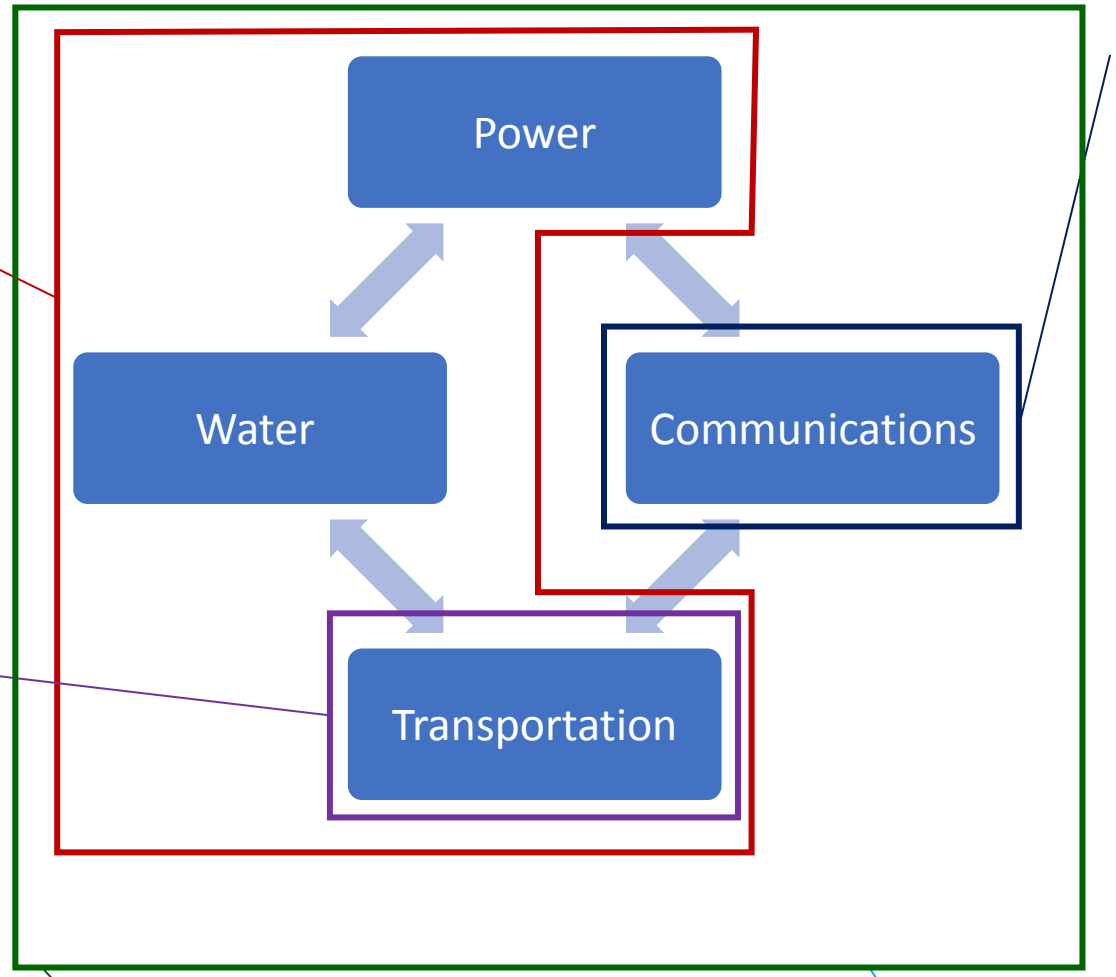
Project plan: Next Steps

Dependencies

Structured interview instruments through IRB, PRA, with fully developed sampling frame

Transportation Incident Analysis

Quality control in consultation with DTOP



Vegetation Remote-Sensing

- 30-m tree cover focal analyses
- Smaller infrastructure study areas

Wireless Communications

- Continue to analyze aerial imagery to categorize all towers as either:
  - Collapsed
  - Still standing--observable damage
  - Still standing--no observable damage
- Determine design codes and hazard levels (modeled wind speeds) for each tower
- Geospatially analyze tower performance as a function of hazard levels and code requirements

Integrative Study

Extend ARC model to include schools, businesses

NWIRP Research Study of Recovery from Hurricane Maria's Impacts on Puerto Rico

Infrastructure Systems Supporting Critical Buildings and Emergency Communications

Project Leader: Ken Harrison

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