

# Infrastructure System Service Outages: Household Impact and Adaptations

## Questions

### Millions of Texans still scramble for drinking water after devastating winter storm

Over 14 million were affected by water service disruptions on Friday morning.

By Morgan Winsor  
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### What would you do if there is no power or water? How do you adapt?

## Background



- People's lives are severely disturbed during infrastructure outages for extreme events and prediction of the response of households is difficult for a large urban city
- Recent research identified the most common user adaptations, such as, using candles or flashlights, purchasing bottled water, reducing or delaying consumption [1]. Another research focused on the unhappiness and willingness to pay to avoid outages [2]
- We aim to answer the below questions which can better accommodate the requirements of the people in the restoration and response activities, using the statistical models, by estimating the aggregate household adaptation profile and impact
  1. How many people are likely to implement different user adaptations in response to water outages?
  2. How many people are likely to be unhappy?
  3. How does the response vary geographically?

## Methodology

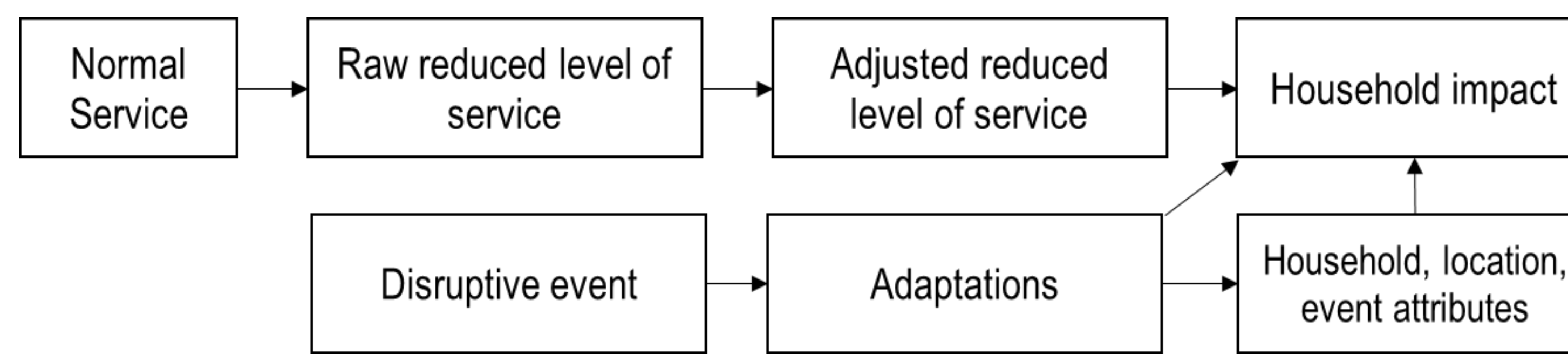


Fig 1: Conceptual framework of the infrastructure system interruptions

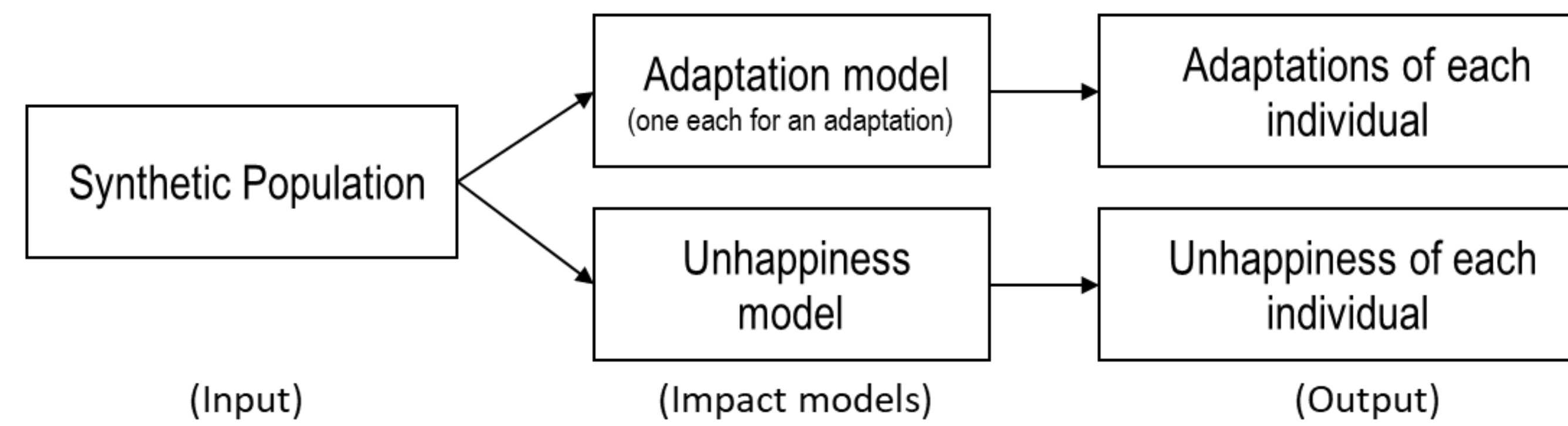


Fig 2: Framework of predicting the response

### Statistical models:

- Based on a revealed and stated preference survey of households regarding response to power and water outages in Los Angeles, California

$$\text{Adaptation, Unhappiness} = f(\text{Infrastructure type, outage duration, household attributes})$$

### Synthetic population:

- 35 significant attributes: Age, income, Presence of elders, children, Presence of someone with a medical condition, risk perceptions etc.

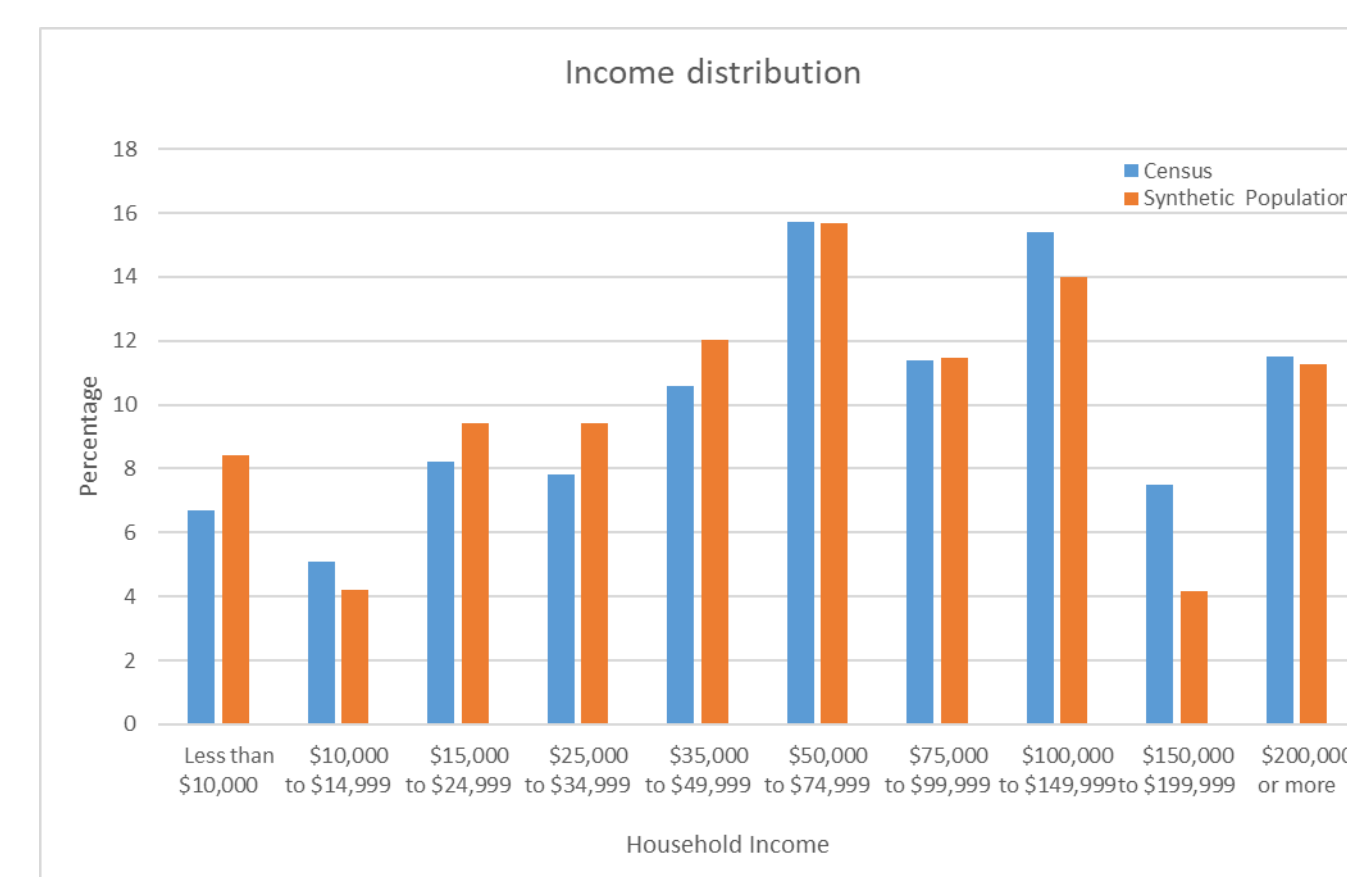
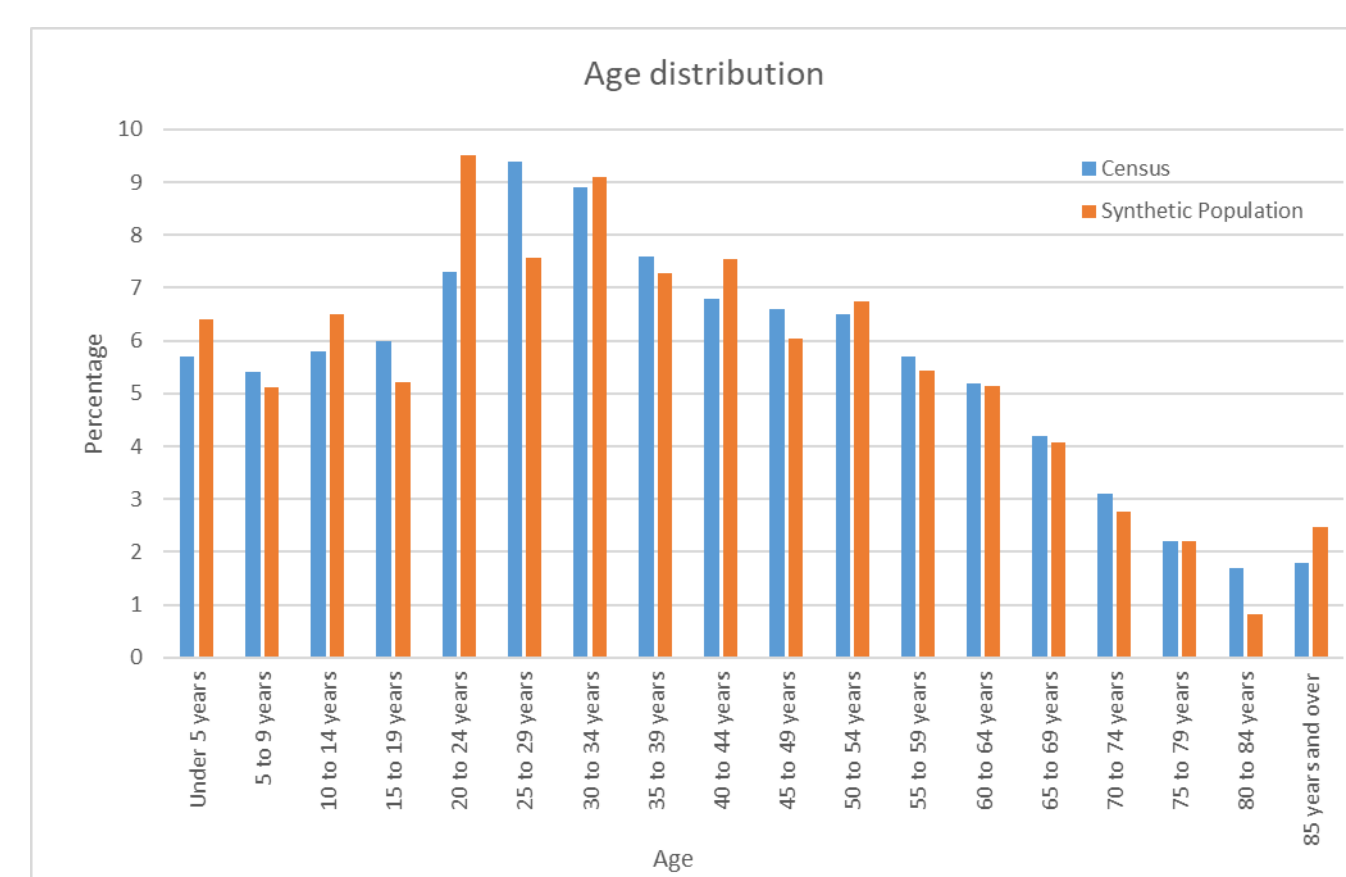
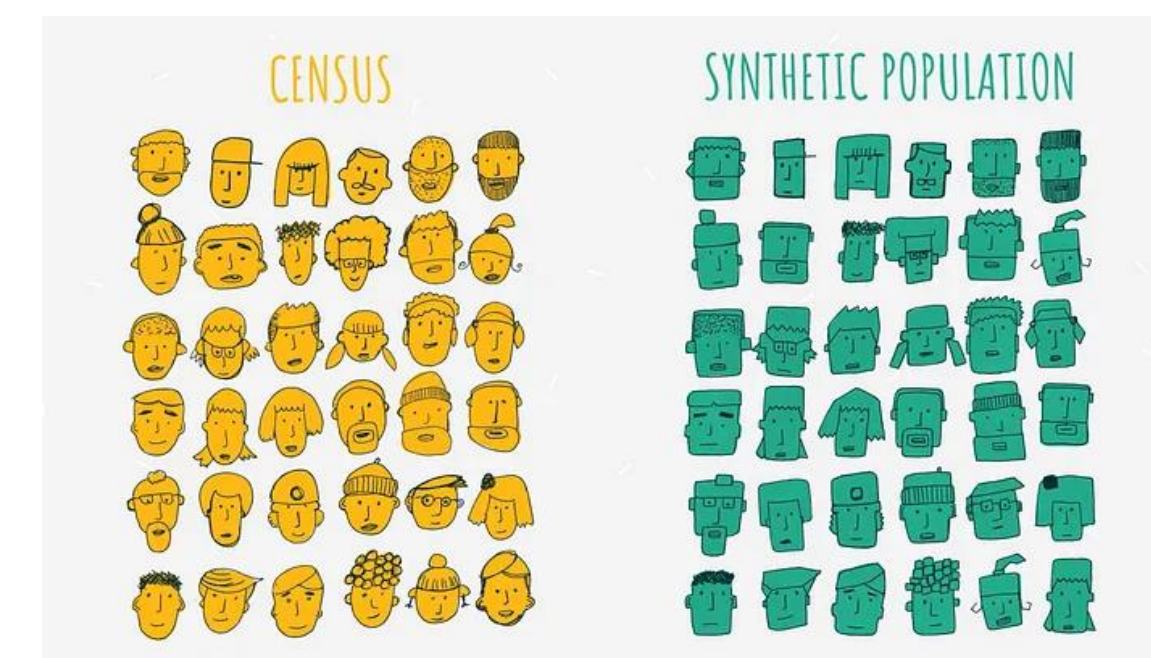
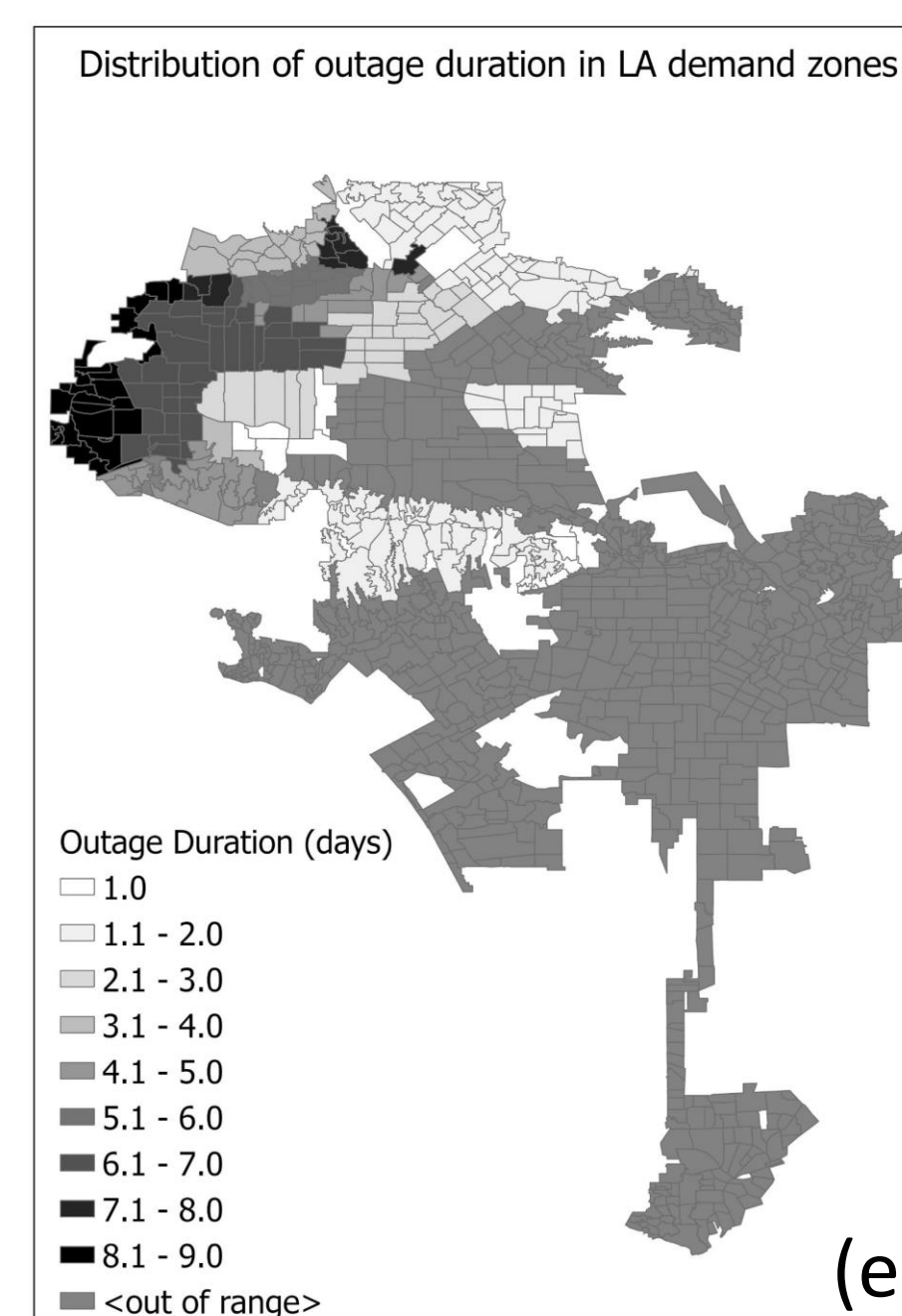


Fig 3: Verification of the developed synthetic population

### Test Scenario:

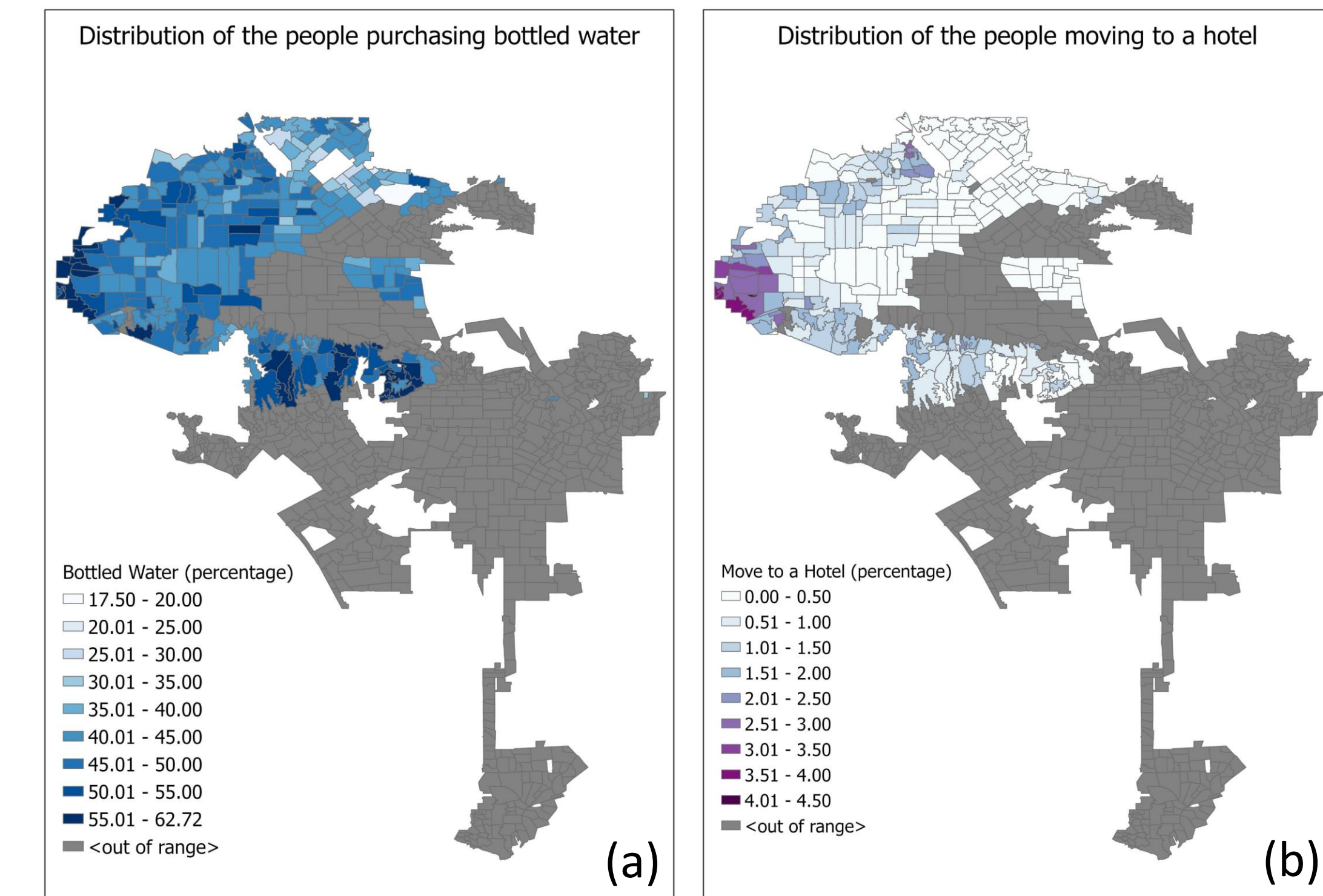
- Study Area: Los Angeles (LA), California (highly populated urban city)
- Study Event: The 1994 Northridge earthquake (impacted LA severely)
- Water outages during the Northridge Earthquake lasted 9 days (e)



## Results

### Estimation of people implementing adaptations:

- Adaptations such as bottled water and consumption delay are implemented by around 45% of the population (Fig. 4)
- Usage adaptations such as bottled water are dependent on local resources and individual user characteristics. (a)
- Moving adaptations such as moving to a hotel or relative's house is guided by length of outage (b)



### Estimation of unhappy people:

- While unhappiness is guided by the length of outage (c, d), there are more than 25% of very unhappy people in the demand zones with lower outages (Fig. 5)
- 60% of the people are very unhappy with a week of outage

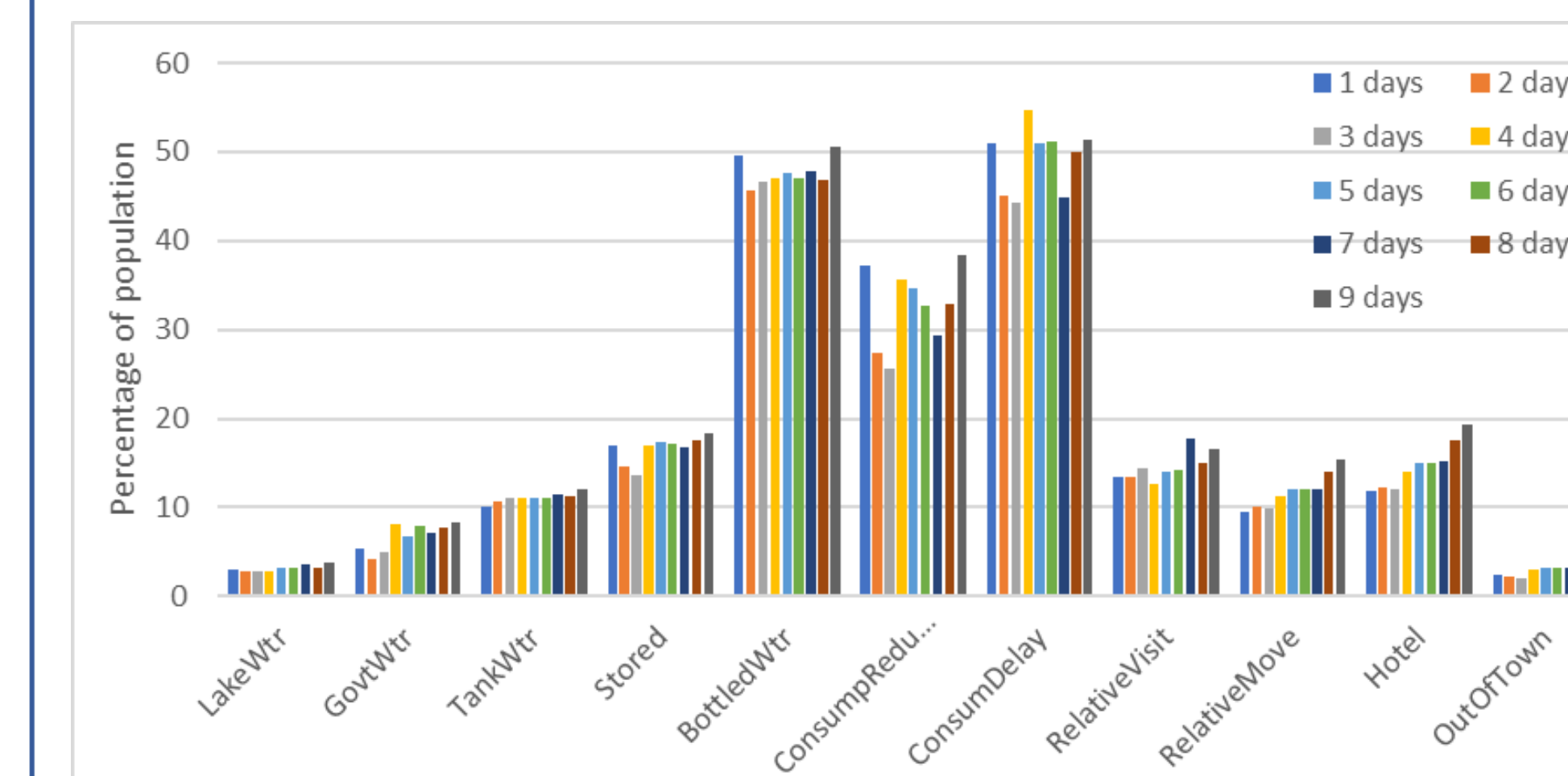
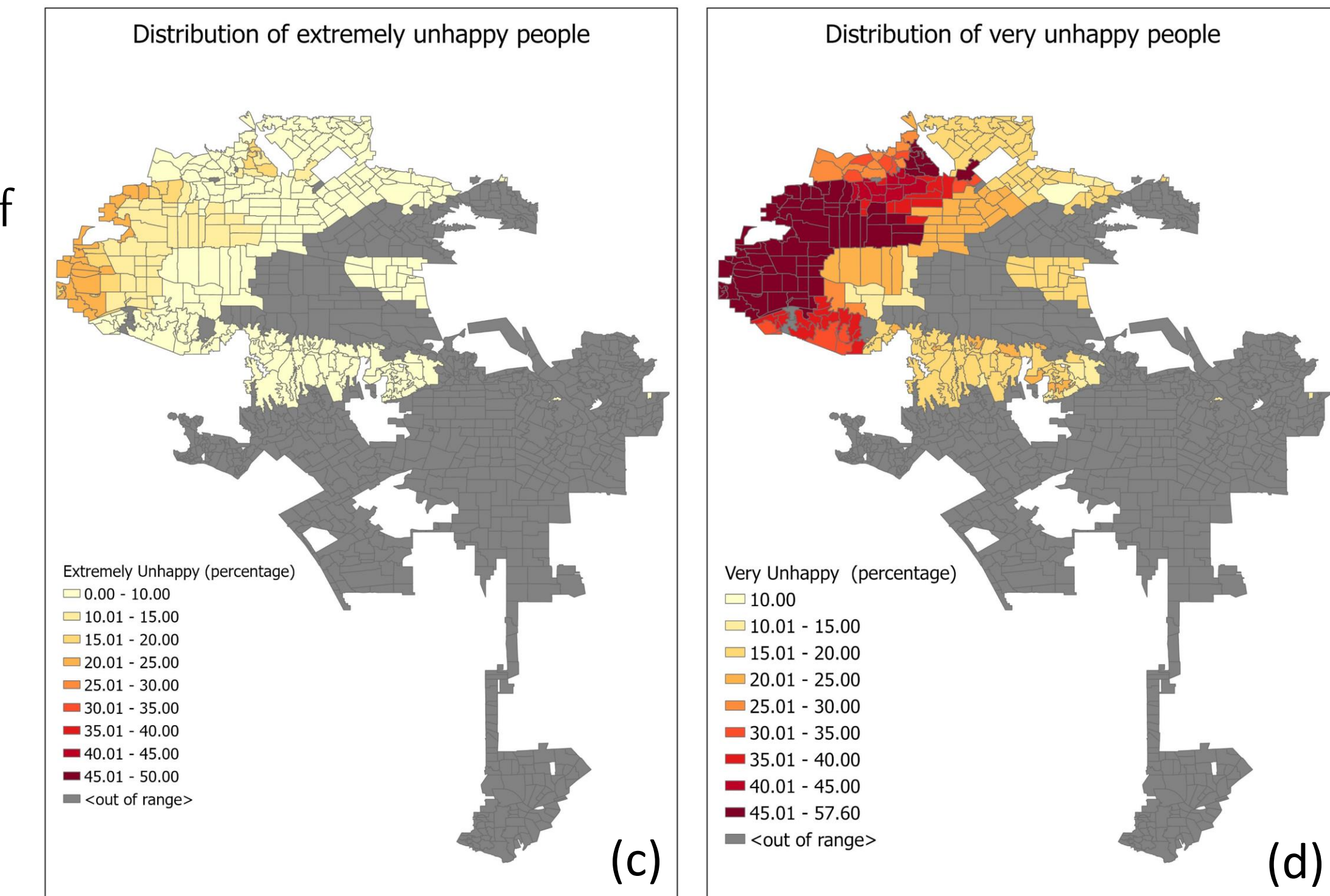


Fig 4: Distribution of people doing an adaptation

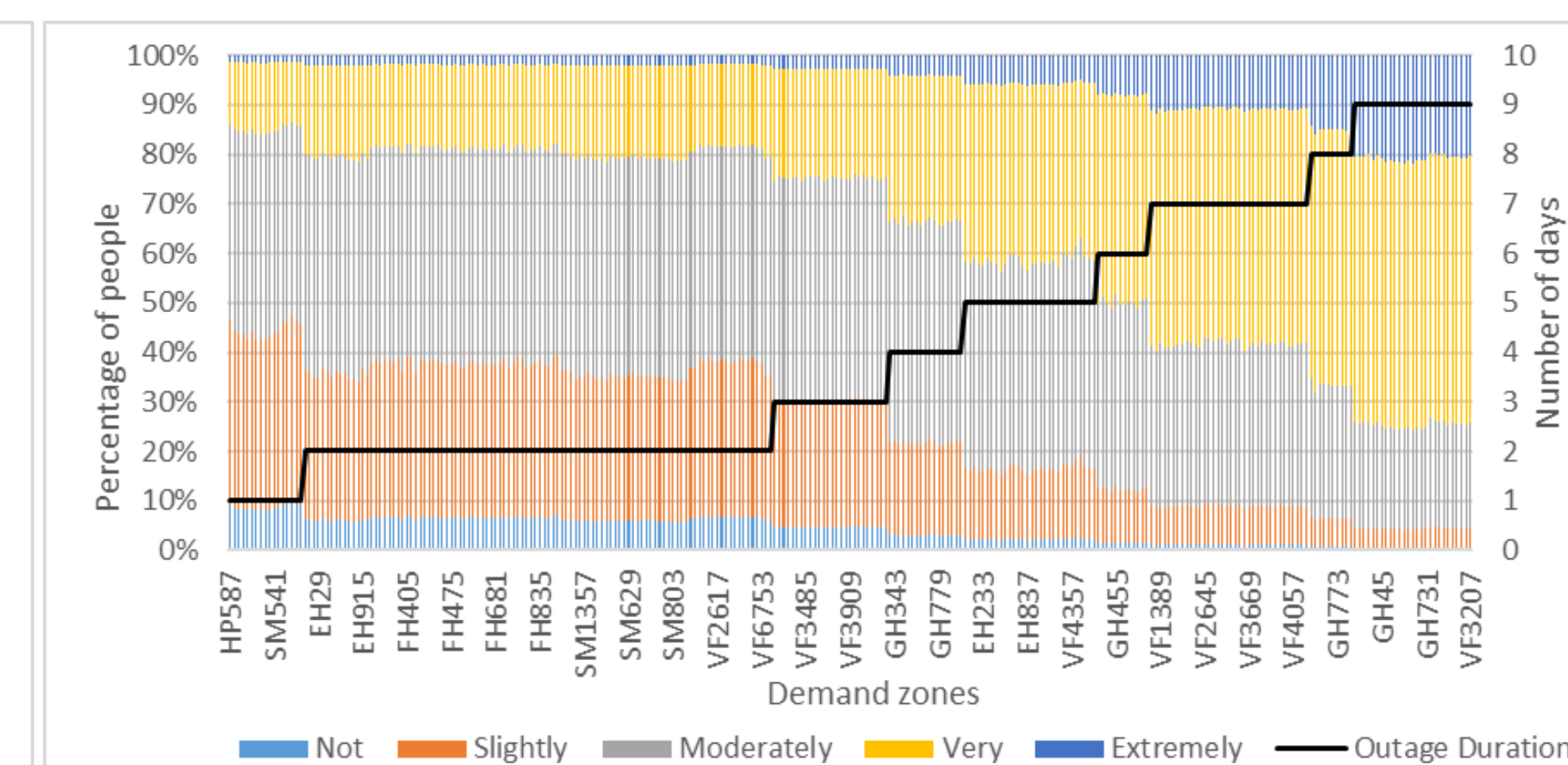


Fig 5: Distribution of unhappy people

## Conclusions

- Our models allow to quantify the consequences of infrastructure outages which can be translated into mitigation measure planning
- This will be very useful to the system operators to estimate the repercussions of the outages
- Popular adaptations are more user dependent than outage duration
- People are likely to move to a relative's house or a hotel as the length of outages increases
- Places experiencing longer outages can have more than 75% of very and extremely unhappy people
- People are found to be very unhappy at even lower outages

### References:

[1] Abbou, A., Davidson, R., Kendra, J., Martins, V. N., Ewing, B., Nozick, L., Cox, Z., and Leon-Corwin, M. 2022. Household adaptations to infrastructure system service interruptions. Journal of Infrastructure Systems. Doi: 10.1061/(ASCE)IS.1943-555X.0000715  
 [2] Stock, A & Davidson, R & Kendra, J & Martins, N & Ewing, B & Nozick, L & Starbird, K & Leon-Corwin, M. (2022). Household impacts of interruption to electric power and water services. Natural Hazards. 115. 1-28. Doi: 10.1007/s11069-022-05638-8.  
 Images: <https://www.tillamookcountypioneer.net/warming-center-open-tonight-tomorrow-december-21st-22nd-2022-first-christian-church-tillamook/>, <https://abcnews.go.com/US/millions-texans-scramble-drinking-water-devastating-winter-storm/story?id=75995619>, <https://www.tribuneindia.com/news/world/british-supermarkets-plea-to-shoppers%E2%80%94panic-buying-55888>, <https://waltonian.eastern.edu/archive/winter-storms-cause-power-outages-across-texas/>, <https://medium.com/data-mining-the-city-2022/module-1-po-9a845c5486ca>

