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Comparative Judgement for Poverty Estimation in Tanzania: Letting the Citizens Decide

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Data and Modelling Uncertainty
Research Priority Area

UKRI Engineering and Physical Sciences Research Council

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Finding Citizens in Poverty

Finding those in poverty

- We want to find citizens who are living in poverty.
- Women and girls living in poverty are at risk of modern-day slavery, Femal Genital Mutilation and high perinatal mortality rates.
- Currently, there are no reliable estimates of poverty rates in Dar es Salaam, Tanzania.

source: https://en.wikipedia.org/wiki/Tanzania

How do we approach this problem?

source: https://www.ft.com/content/380c2bd4-116b-11e3-a14c-00144feabdc0

NOTTINGHAMSHIRE POLICE
PROUD TO SERVE

source: https://www.police.uk/nottinghamshire/

NHS

source: https://en.wikipedia.org/wiki/National_Health_Service_(England)

How do we do this in Tanzania?

“It’s no longer a crime to publish statistics in Tanzania”

The Citizen, 29th June 2019

How do we get around this problem?

Citizens

Know the local area

Have up to date knowledge

Are enthusiastic

Are expensive to ask

May be biased

Need to be sampled

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Comparative Judgement Data

Different Types of Judgements

Absolute Judgement

West Bridgford is the best place the live.

List Judgement

1. West Bridgford
2. The Park
3. Wollaton
4. The Lace Market
5. Beeston

Comparative Judgement

The Park

is nicer than

Beeston

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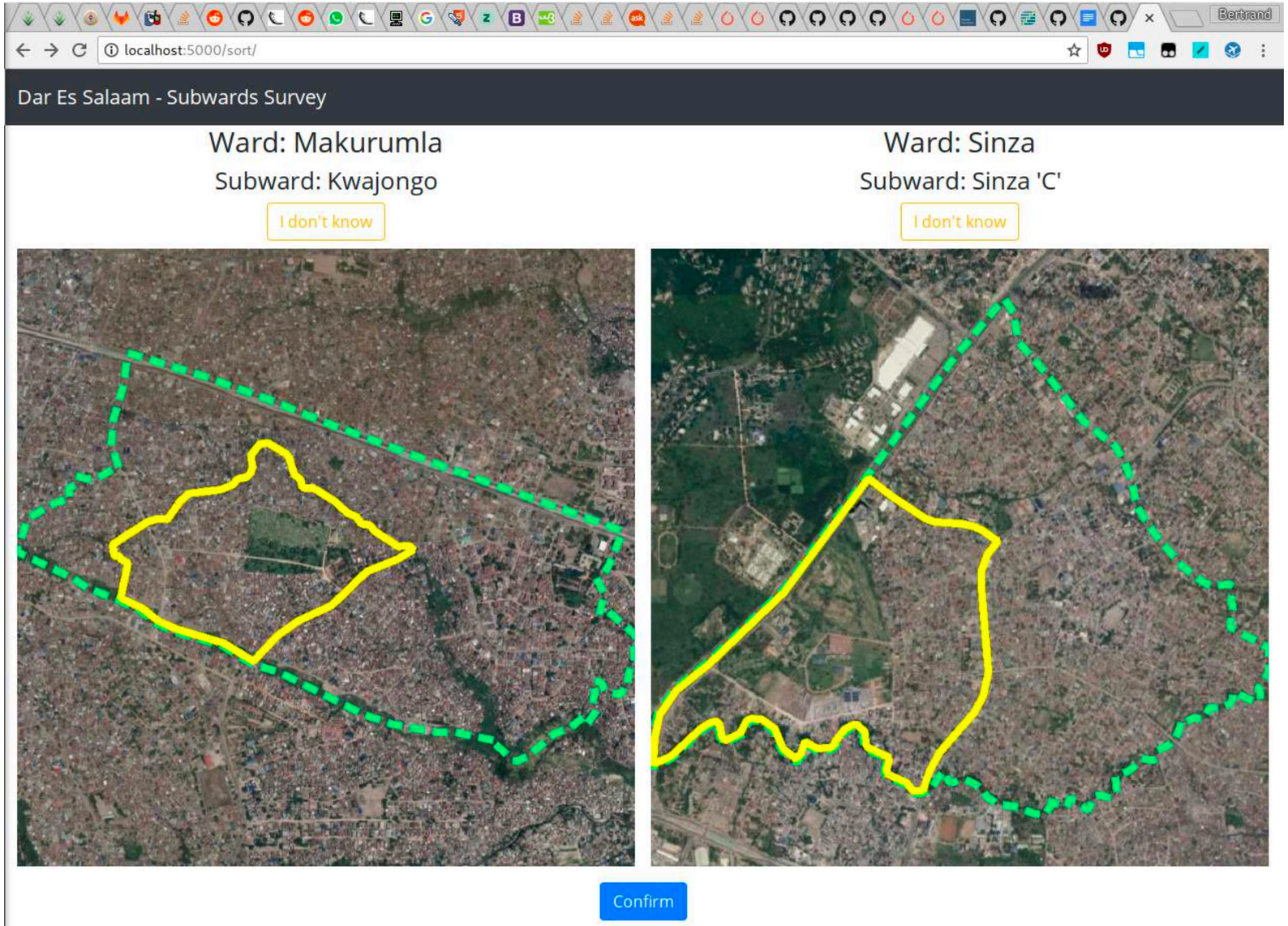
Comparative Judgement in Dar es Salaam



Comparative Judgement in Dar es Salaam

Two weeks in August 2018

173 Volunteers

75,457 Comparisons

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Comparative Judgement Methods

The Bradley-Terry Model

- Y_{ij} is the number of times i beats j
- $\boldsymbol{\pi}_{ij}$ is the probability i beats j
- $\boldsymbol{\lambda}_i$ is the quality of subward i

$$Y_{ij} \sim \text{Binomial}(n_{ij}, \pi_{ij})$$

$$\pi_{ij} = \frac{\lambda_i}{\lambda_i + \lambda_j}$$

- All judgements are independent
- All judges have the same perception of each subward

$$\text{logit}(\pi_{ij}) = \lambda_i - \lambda_j$$

Including a Spatial Element

We assume the level of poverty in each subward depends on its location in the city, the suburb it's in, and its immediate neighbours.

$$\lambda_i = p_1 f_{city}(x_i, y_i) + p_2 f_{suburb}(x_i, y_i) + p_3 f_{neighbour}(x_i, y_i)$$

We model the functions non parametrically using Gaussian Processes.

$$f \sim \mathcal{GP}(0, \Sigma)$$

The parameters p_1, p_2, and p_3 describe how important each function is.

Including Judge Noise

We allow for each judge to have a different perception on each subward.

$$\lambda_{ig} \sim N\left(\lambda_i, \sigma_g^2\right)$$

The noise parameter for judge g, $\boldsymbol{\sigma}^2_g$, tells us how reliable judge g is.

This increases the number of parameters in the model:

- 173 reliability parameters
- 173*452 = 78,196 perceived quality parameters.

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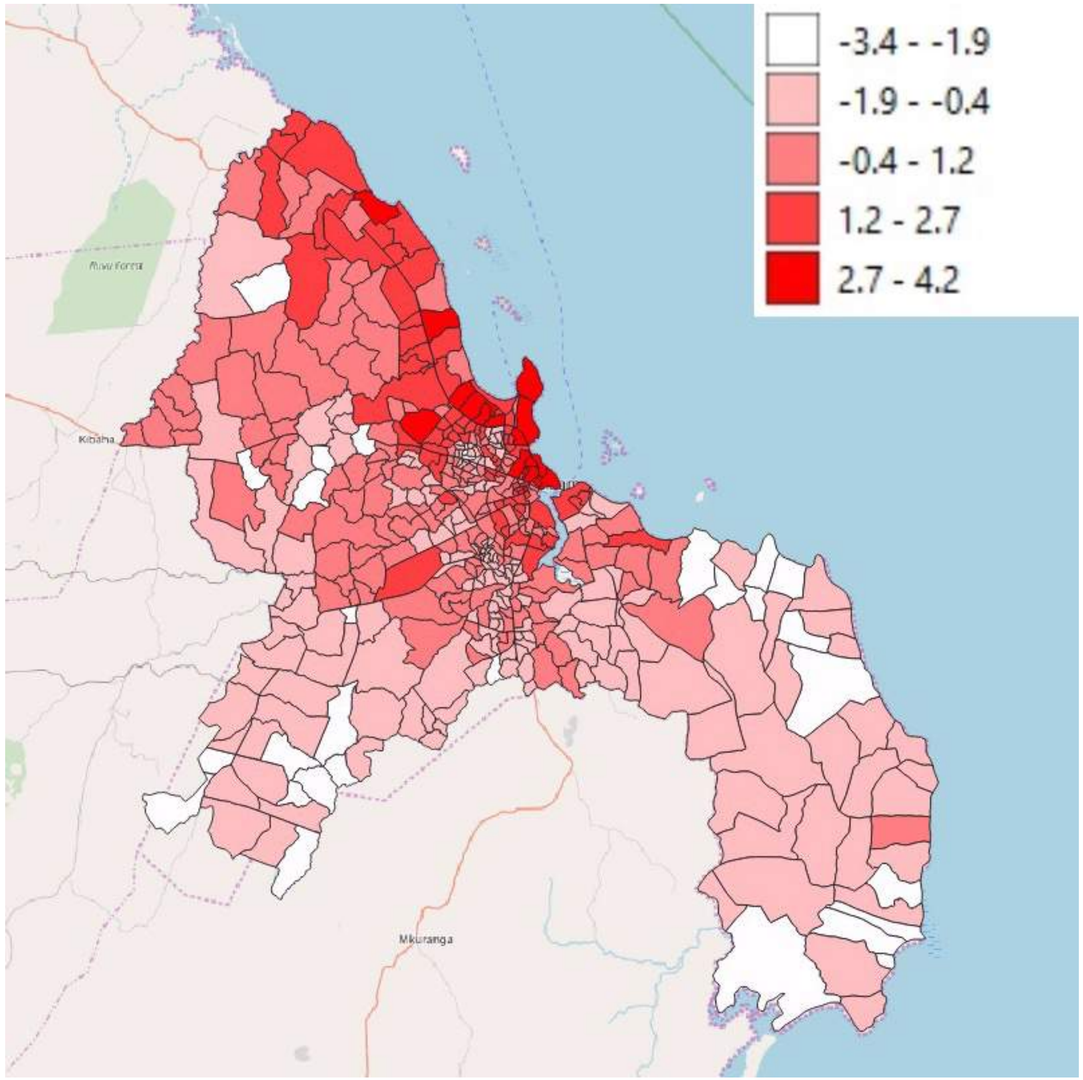
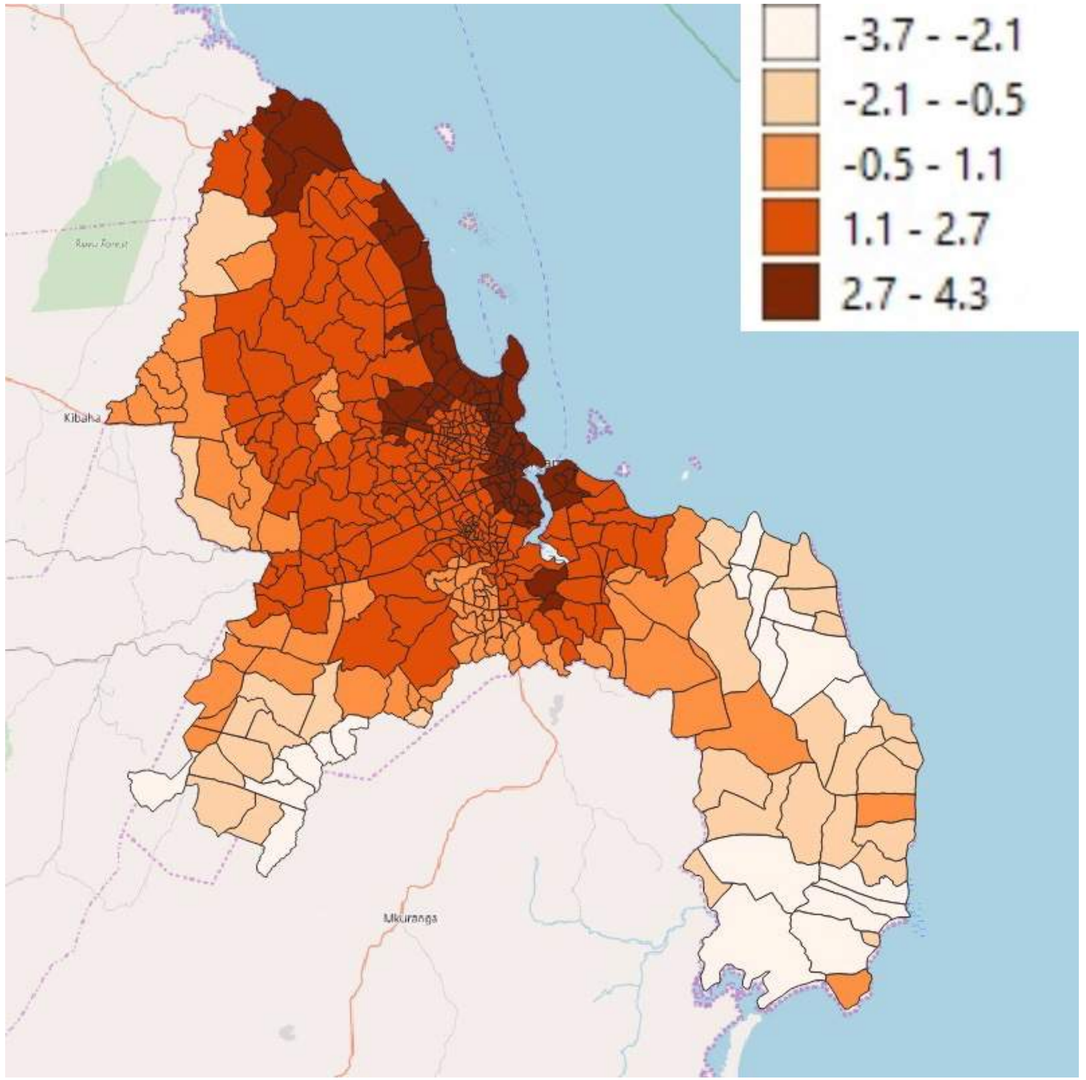
Results for Dar es Salaam

Results for Dar es Salaam



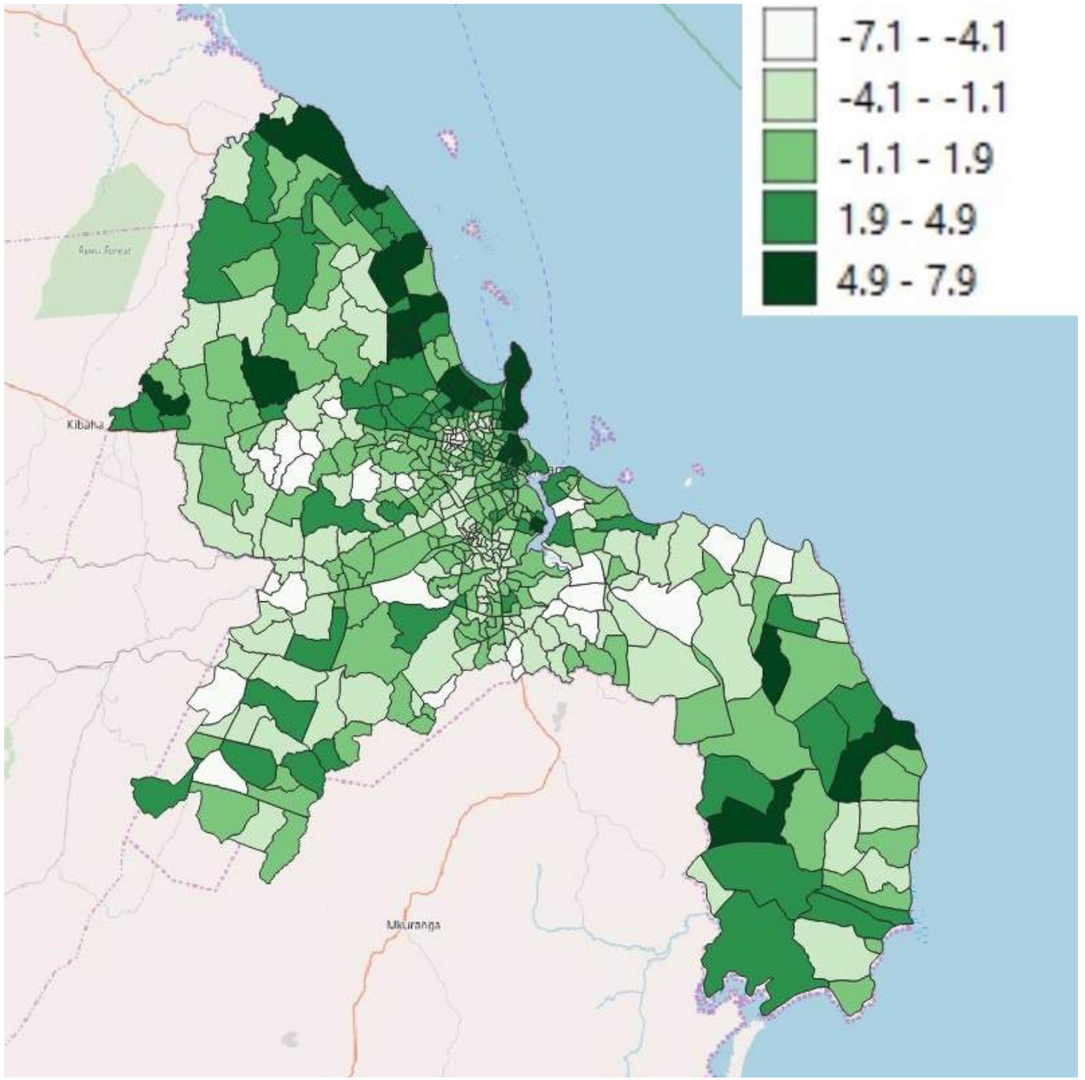
The vulnerability level for each subward

City Wide Results

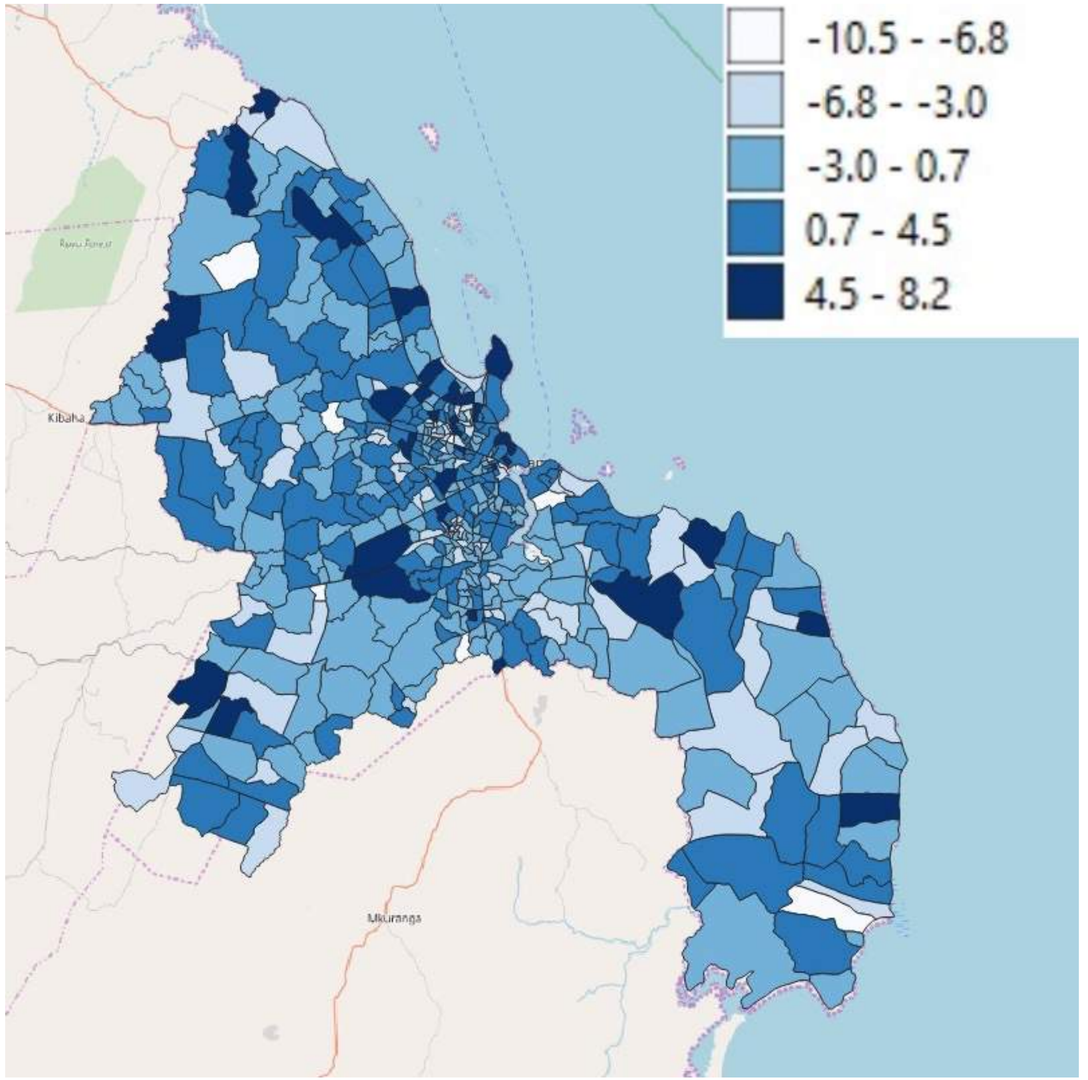


The city-wide vulnerability function

Suburb Level Results

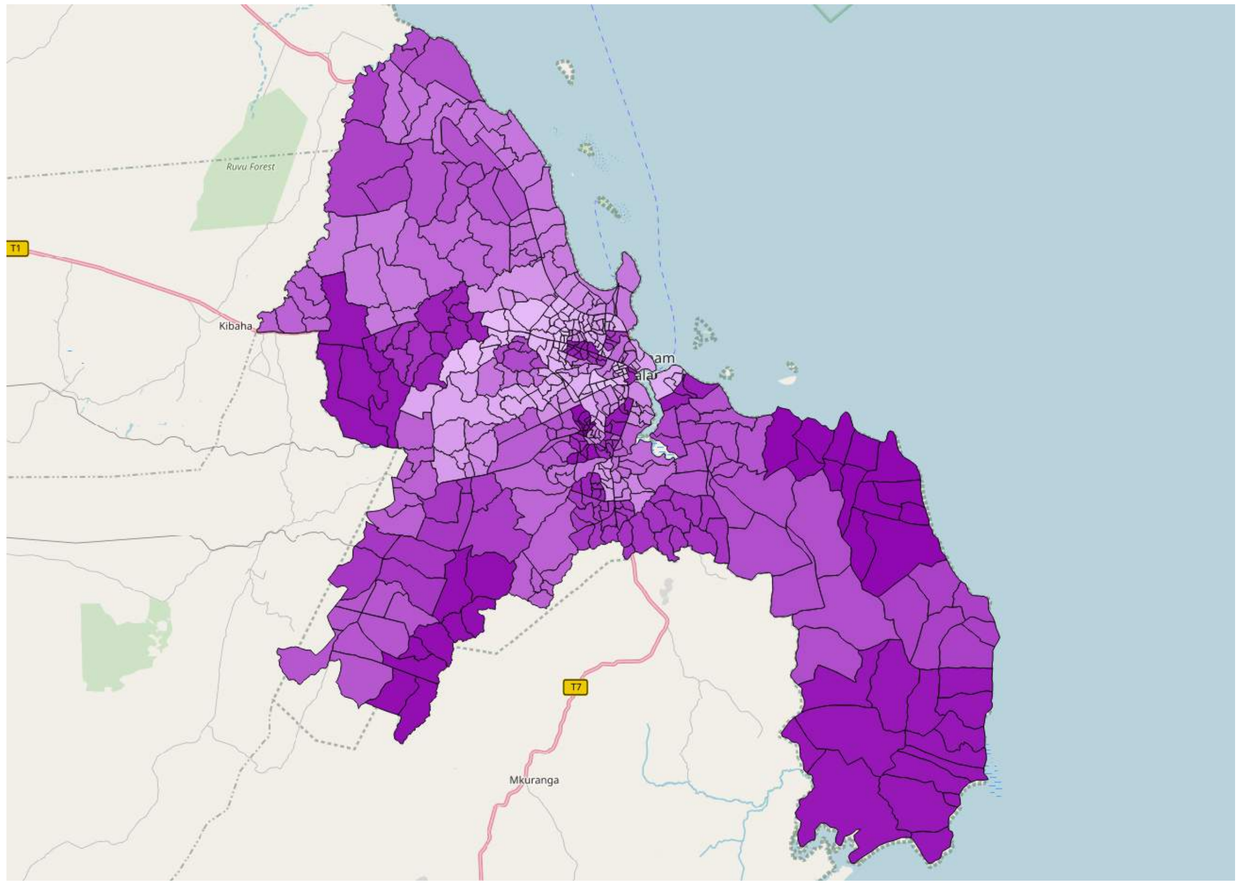


The suburb level vulnerability function

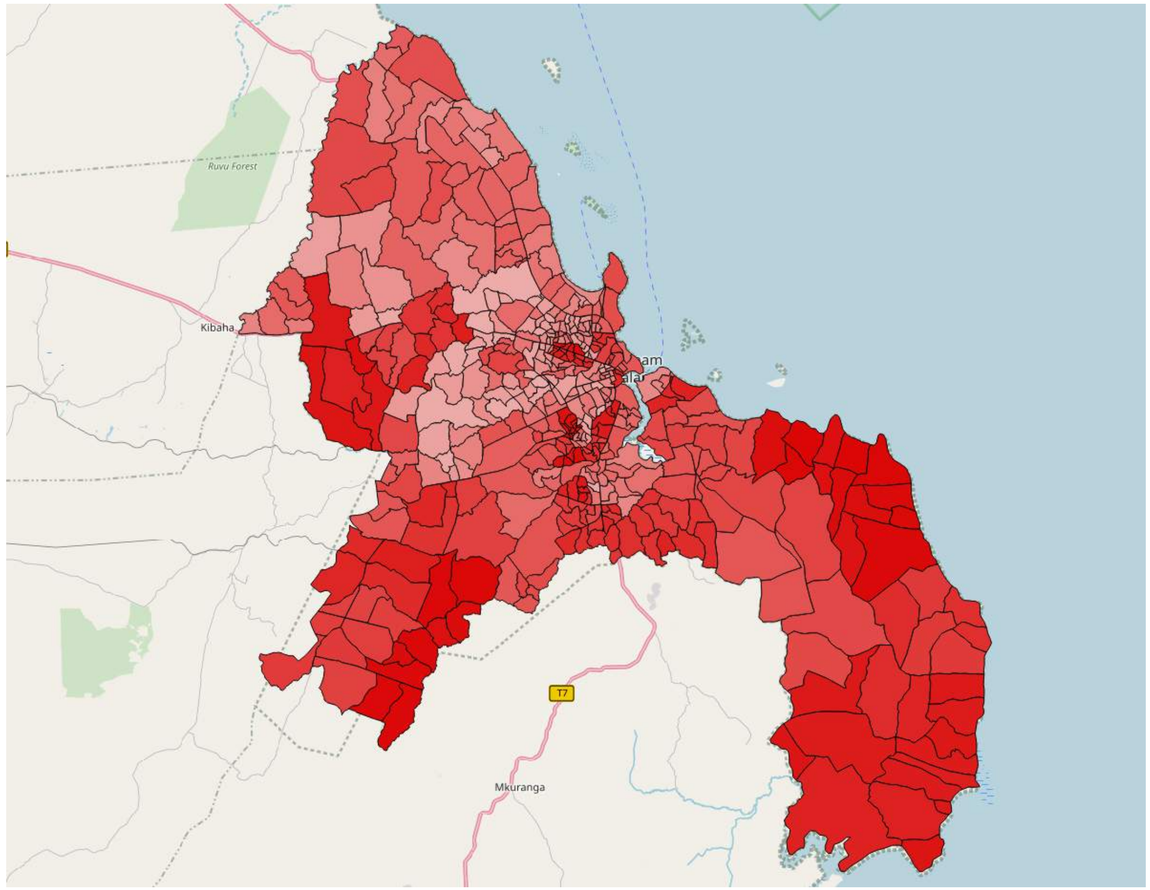


The neighbourhood level vulnerability function

Quantifying Uncertainty in the Results



Proportion of judges who knew each subward



Uncertainty in results

Judge Reliability

The judge reliability results are still a work in progress. So far we have found:

- The vast majority of judges agree on the vulnerability in each subward.
- We need to do a better job at finding citizens from all over the city.
- First thing in the morning and after lunch are the best times to collect data.

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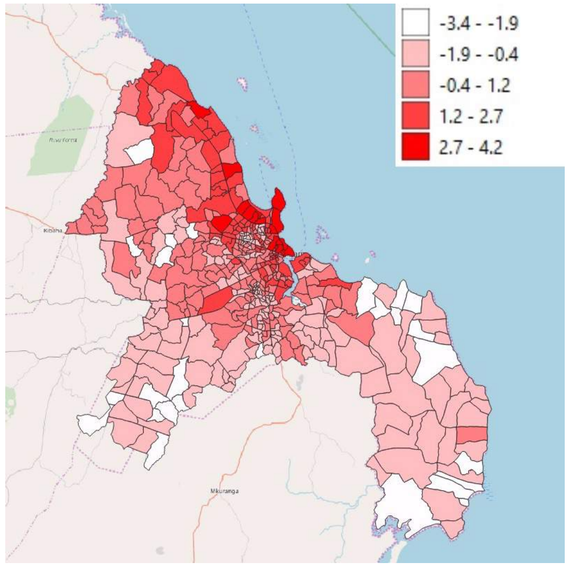
Letting the Citizens Decide

Conclusion

“It’s no longer a crime to publish statistics in Tanzania”

$$Y_{ij} \sim \text{Binomial}(n_{ij}, \pi_{ij})$$



$$f \sim \mathcal{GP}(0, \Sigma)$$

Any Questions?