

# Small area population estimates in high-rise buildings: A case study in Thailand

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## Introduction

Effective policymaking and equitable resource allocation often require accurate knowledge of population numbers within a small area unit of interest. However, in many countries, barriers to collection of demographic data can exist. In Thailand, residential high-rise buildings and gated communities can often be inaccessible to enumerators, thereby leaving population data gaps. Here, we present a novel component-wise population modelling approach for producing population estimates and estimates of uncertainties within high-rise buildings and gated communities.

## Data Description

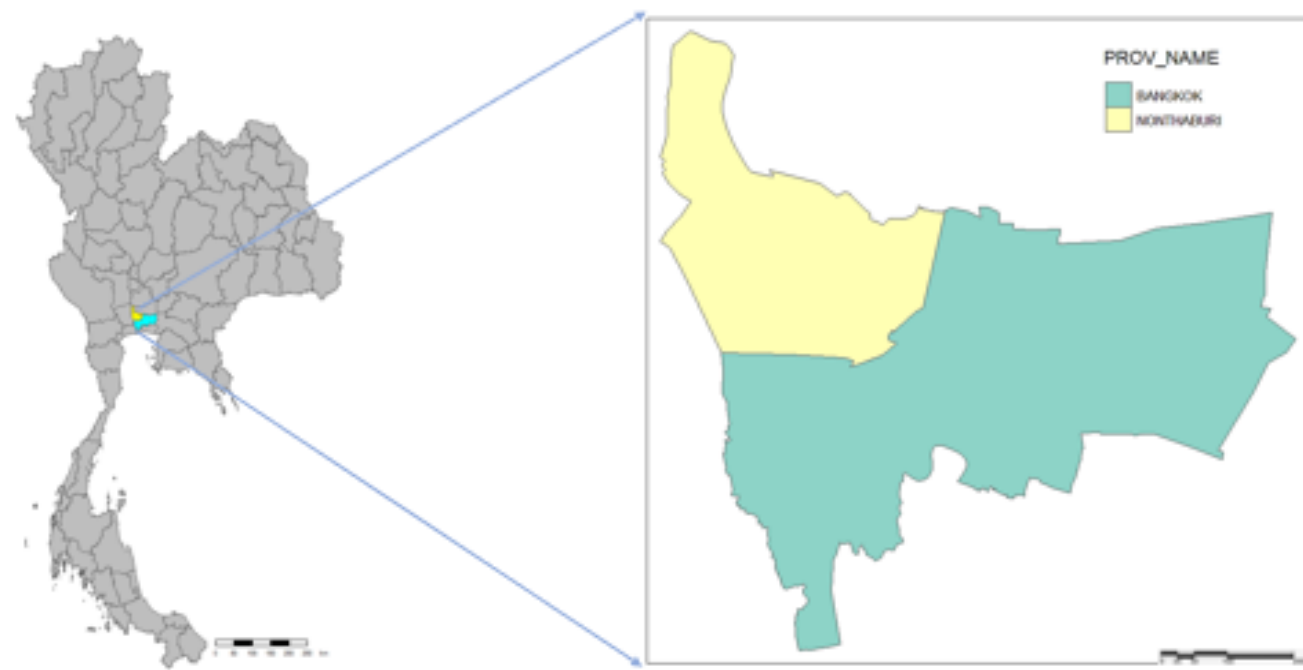


Figure 1. Nonthaburi and Bangkok Provinces

- Datasets were available for Nonthaburi and Bangkok Provinces (Figure 1)
- Both provinces contain accessible and inaccessible high-rise buildings and gated communities
- Datasets were available at the Enumeration Area (EA) level
- We focused on all of the EAs in the six districts in Nonthaburi and two districts in Thailand
- Where data were available, there were information on
  - Number of floors (if a high-rise)
  - Number of households
  - Number of rooms
  - Number of people
  - Populations counts by age/sex

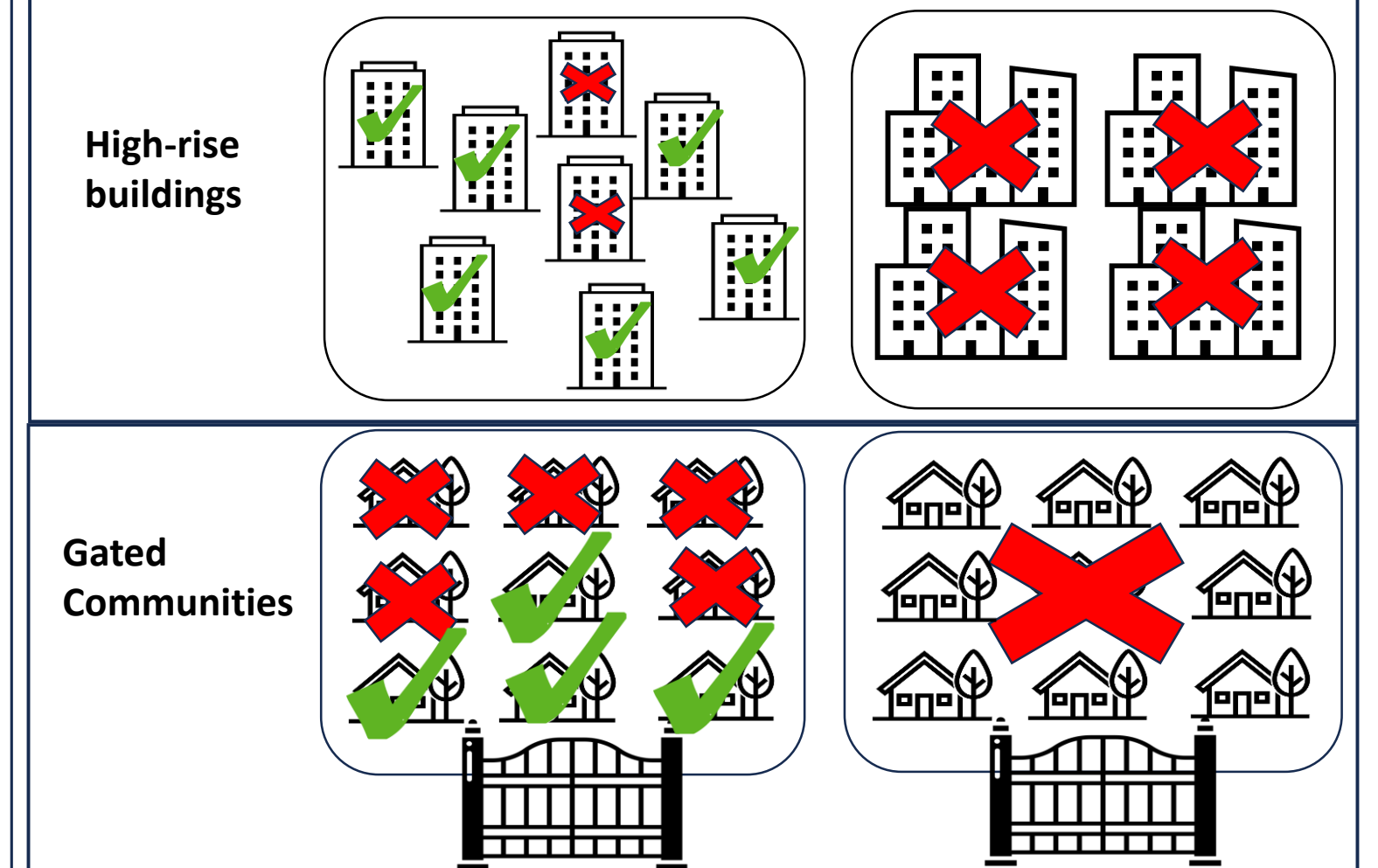
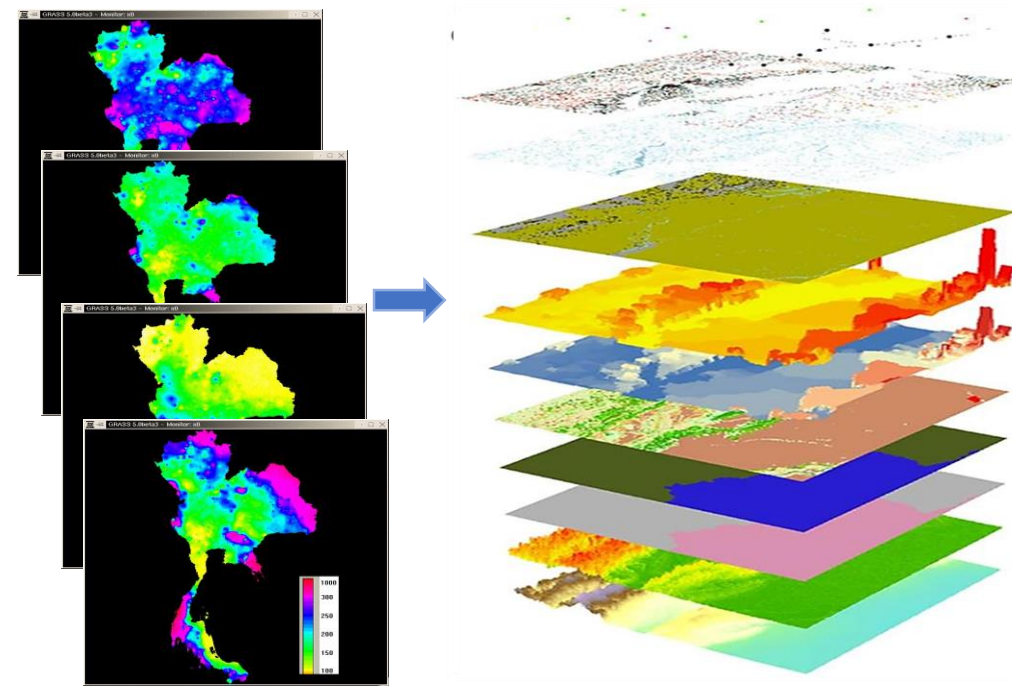
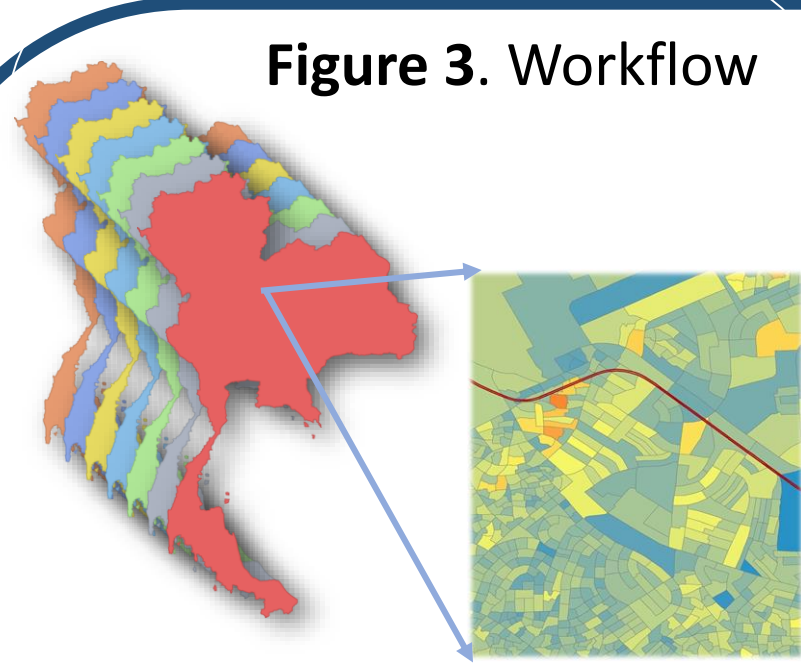


Figure 2. Data scenarios in high-rise and gated communities

## Methodology



Population/demographics

Buildings/settlement

Geospatial covariates

- First, we defined population density as count of people per building ( $ppb$ )
- We used a component-wise approach to define population density in order to account for variabilities due to floors, households and buildings differences.
- Specifically, our proposed model defined population density as the product of people per households ( $pph$ ), households per floor ( $hpf$ ), and floors per buildings ( $fpb$ ).
- We carried out a GLM-based stepwise selection to choose the best geospatial covariates for the models for Bayesian hierarchical modelling (Figure 3).
- Predictions were then made to obtain counts across the inaccessible areas following model checks and model cross-validations

### Model Specification:

$$pop_i \sim \text{Poisson}(\mu_i B_i)$$

$$\mu_i = pph \times hpf \times fpb$$

$$\log(pph) = \alpha + X\beta + \phi_i$$

$$\log(hpf) = \alpha + X\beta + \phi_i$$

$$\log(fpb) = \alpha + X\beta + \phi_i$$

$$\phi_i \sim \text{GMRF}$$

$$\hat{\mu} = \hat{fpb} \times \hat{hpf} \times \hat{pph}$$

- $pop_i$ : count of people per EA
- $\mu_i$ : Average density
- $B_i$ : Number of people
- $pph$ : people per household
- $hpf$ : households per floor
- $fpb$ : floors per building
- GMRF: Gaussian Markov random field

## Results

- When applied to Nonthaburi province and Don Mueang districts, The parameters of the best fit models (Table 1), were used to predict population across the entire EAs of interest (e.g., Figure 4, for Nonthaburi).
- Results were also disaggregated by age and sex (Figure 5)

Table 1: Model fit metrics

	BIAS	Imprecision	Inaccuracy	RMSE	Corr
Nonthaburi - Don Mueang	-16.3	110.06	70.57	110.96	0.89
Don Mueang	-2.46	29.99	21.71	29.78	0.95

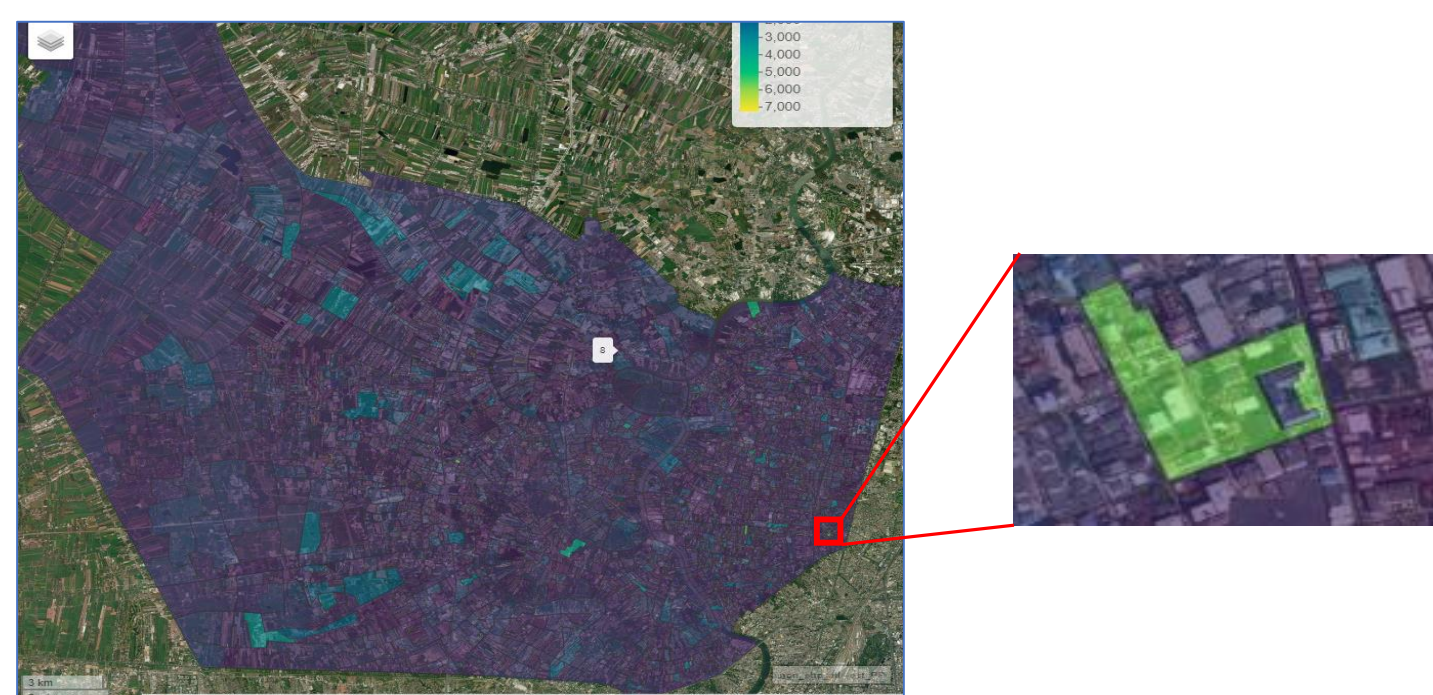


Figure 4. Predicted population across Nonthaburi province

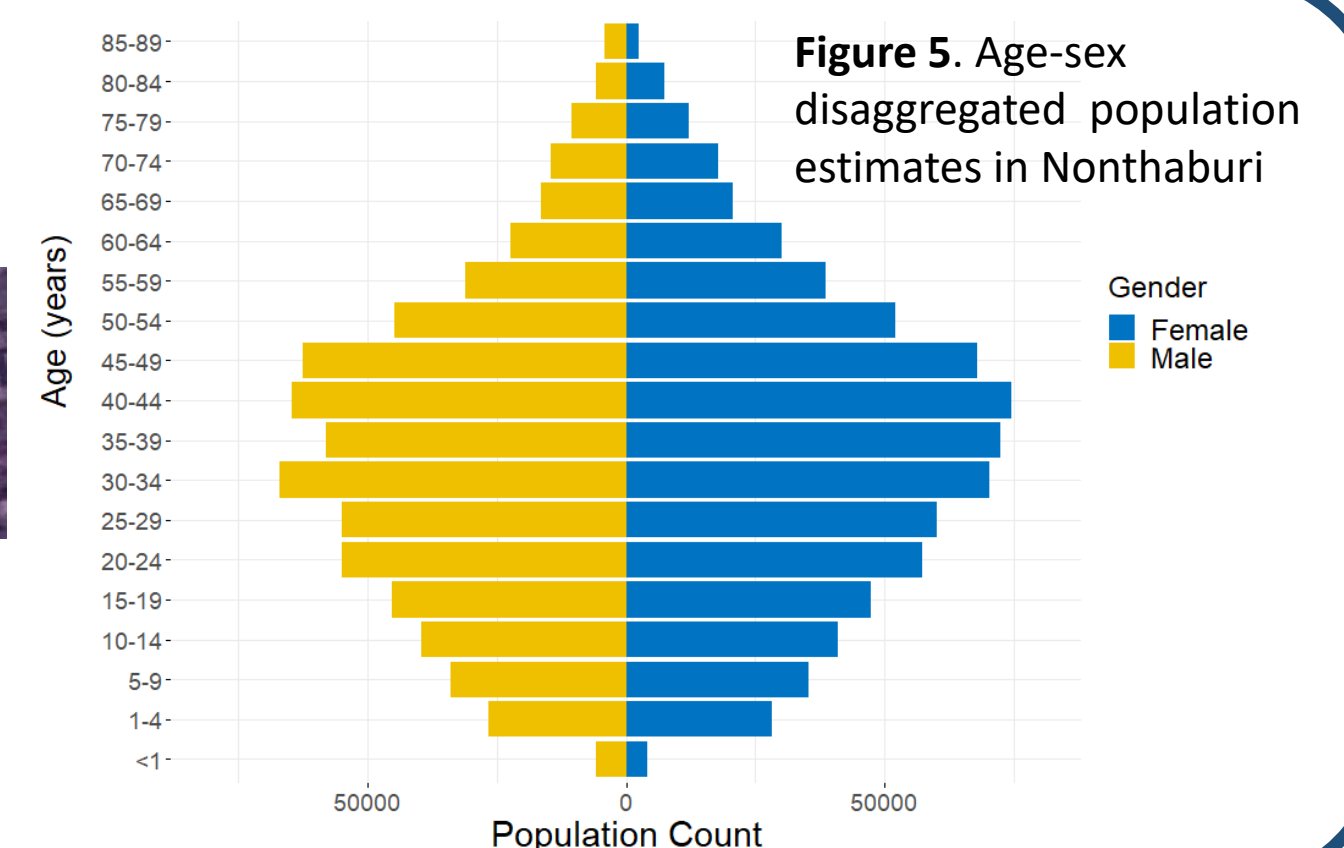


Figure 5. Age-sex disaggregated population estimates in Nonthaburi

## Bibliography

- [1] Rue, H., Martino, S., & Chopin, N. (2009). Approximate Bayesian inference for latent Gaussian models by using integrated nested Laplace approximations. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, 71(2), 319–392.
- [2] Lindgren, F., Rue, H., & Lindström, J. (2011). An explicit link between Gaussian fields and Gaussian Markov random fields: The stochastic partial differential equation approach. *J. R. Stat. Soc.: Ser. B (Stat. Methodol.)* 73, 423–498.