Methods for Modeling Human Population in Rural Kenya: A Case Study in Trans Nzoia County

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Introduction

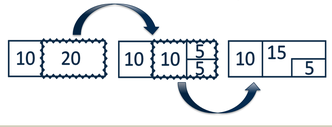
As part of a larger project examining land justice and tenure in Kenyan smallholder settlement schemes, I developed models to estimate population distribution among schemes in the pilot county of Trans Nzoia. My goal was to develop a simple method of disaggregation and reaggregation that could be easily implemented across the entire project. I first employed four comparative methods using vector-based dasymetric areal interpolation, and compared them to the 100 m x 100 m resolution gridded population density data from the AfriPop dataset made available at Worldpop.org (Linard et al., 2012). Additionally, I attempted this semester to develop a more accurate model using satellite imagery to identify homes for use in the same manner.

Background

•After Kenya gained independence in 1963, settlement schemes were established to deracialize landholding, promote economic development, and provide land to displaced people.
•To date, 546 settlement schemes have been established, totaling nearly 1,000,000 HA.
•The National Land Commission (NLC) was constitutionally established in 2012 and was tasked with carrying out the mandates of article 68 of the Constitution of Kenya.
•Since the 1980's, little scholarly research has been conducted on the settlement schemes. (Lukalo and Odari, 2017).

Theory

• When estimating population, size disparities often exist between administrative units and units of study.
• Choropleth population data assumes a homogeneous distribution.
• Dasymetric mapping involves the disaggregation of data using an ancillary spatial data set (Mennis, 2003).
• Areal interpolation accuracy can be improved by removing uninhabited areas from large initial administrative units or by moving population into likely areas of habitation (Owens et al., 2010).



Vector-based Models

•**Area-Weighted**–Performed areal interpolation from wards to schemes without ancillary data.
•**Land Use Vector**–Interpolated ward populations to Plantation and Dense Agriculture zones of an ILRI Land Use vector layer, then to schemes.
•**1 km Road Buffer**–Interpolated ward populations to a polygon consisting of a 1km planar buffer placed around all continually passable roads in the county, as derived from OSM and KRB data, then to schemes.
•**0.5 km Road Buffer**–Same as above, using a smaller linear unit.
•**AfriPop**–Interpolated gridded population estimates from AfriPop classified raster directly into schemes.

Works Cited:
Linard, C., Gilbert, M., Snow, R.W., Noor, A.M. & Tatem, A.J. (2012). Population Distribution, Settlement Patterns and Accessibility across Africa in 2010. *PLoS ONE* 7(2), e31743.
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Mennis, J. (2003). Generating Surface Models of Population Using Dasymetric Mapping. *The Professional Geographer* 55(1), 31–42.
Owens, P.M., Titus-Ernstoff, L., Gibson, L., Beach, M.L., Beauregard, S. & Dalton, M.A. (2010). Smart density: a more accurate method of measuring rural residential density for health-related research. *Int. Journal of Health Geography* 9(8), 1-8.
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Comparison Map of Vector-Based Models

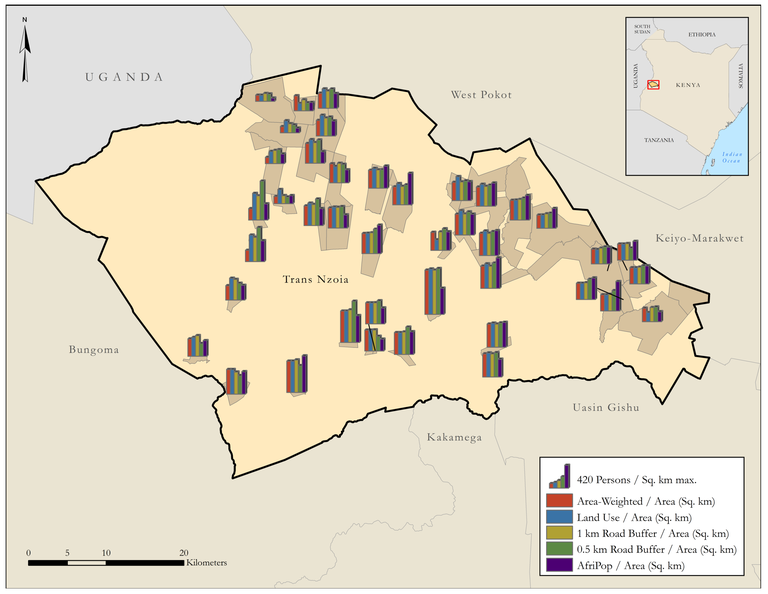

Figure 1. Comparison of population density by model within each settlement scheme in Trans Nzoia County.

Results of Vector-Based Models

Table 1. Summary of mean and SD between each model and AfriPop data.

VARIABLE	MEAN	SD
Area-Weighted	3447	3665
Land-Use Vector	3696	3704
1km Road Buffer	3719	3863
0.5km Road Buffer	3919	4128
Afripop	3737	4457

Table 2. Test statistics and significance of paired t-tests between model data and AfriPop data.

VARIABLE	t	Sig. (2-Tailed)
Area-Weighted	1.262	0.21
Land-Use Vector	0.179	0.86
1km Road Buffer	0.080	0.94
0.5km Road Buffer	0.858	0.40

Discussion and Complicating Factors:

- 1 km Road Buffer method most closely replicates AfriPop data *in Trans Nzoia County.*
- Variation in road data quality in other counties could cause significant differences in resulting accuracy during replication attempts.
- Because of this, a method that relies on consistent, nationwide imagery is likely to return more precise and uniform estimates.

Imagery-Based Methods

- Obtained PlanetScope imagery from Planet.com using a research license.
- Created mosaic dataset with imagery.
- Used clip to isolate Kaplamai Ward.
- Replaced band 3 (blue) with NIR for better reflectance from metal roofing.
- Converted to grayscale for single value raster cells.
- Determined minimum rooftop value by selecting cells surrounding structures.
- Used select by attribute to select all cells with values greater than 950.
- Used raster to polygon to create polygon layer of all selected cells.
- Compared polygon layer to basemap imagery to check for accuracy.

Detail Map of Imagery-Based Model Result

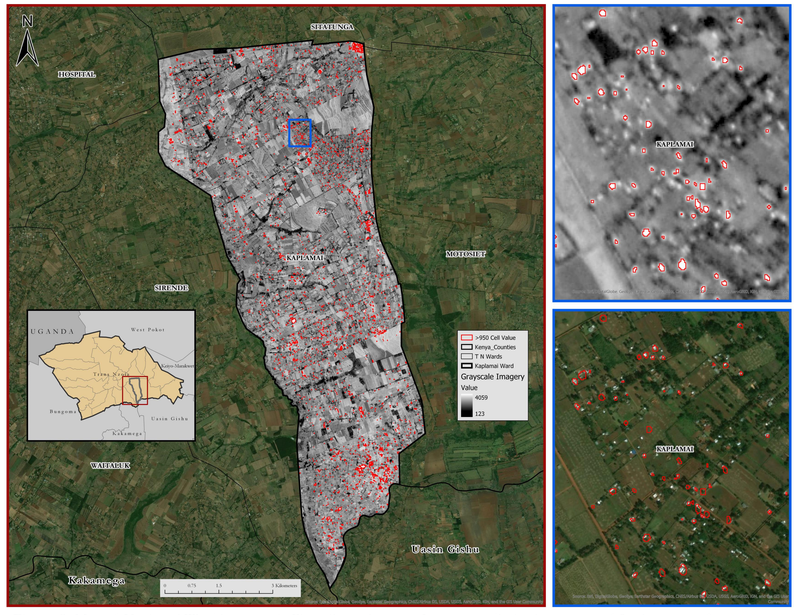

Figure 2. Map of Kaplamai Ward in grayscale PlanetScope imagery. Inset maps display inaccuracy of 3m imagery reflectance when compared with high-resolution basemap imagery. (Note the many structures not identified using only reflectance values.)

Discussion and Future Work

- PlanetScope 3m data is of insufficient precision for accurate structure ID.
- Secure funding in the fall to obtain .7m data for improved precision.
- Use eCognition software to identify homes by size and shape vs. reflectance.
- Dasymetrically map populations using homes as the unit of disaggregation.